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Life Cycle Assessment of Disposable and Reusable Nappies in the UK

Environment Agency

The project was informed and assisted by an Advisory Board set up by the Environment Agency. Membership of the Advisory Board was decided by the Environment Agency on the basis of interest, balance and ability to assist in data collection.

The Advisory Board members were:

- Stewart Begg – Absorbent Hygiene Product Manufacturer Association (AHPMA);
- Terry Coleman (*Chairman*) - the Environment Agency;
- Geoff Davies - Swindon Unitary Authority;
- Dr Ioannis Hatzopoulos – Procter & Gamble Service GmbH;
- Ann Link - Women's Environmental Network;
- Joanna Marchant - the Environment Agency;
- Gillian Neville – Defra;
- Vicki Portman - Plush Pants (one meeting); and
- Gina Purrman – Real Nappy Association (resigned from Real Nappy Association Spring 2003. Replaced on the Advisory Board by Joanne Freer - Cotton Bottoms).

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Foreword

Even though we now recycle nearly 18 % of our 25 million tonnes of household waste we still landfill the majority of the remaining waste. We need to continue with the programme of actions to deliver much greater recovery and reuse of these materials.

As we re-examine the impacts of what we produce, and the waste we generate we need a framework to decide what makes sense. That is where Life Cycle Assessment (LCA) can be used. It forces a rational examination of all the environmental impacts of products and services.

2-3% of our household waste is estimated to be disposable nappies, approximately 400,000 tonnes of waste each year.

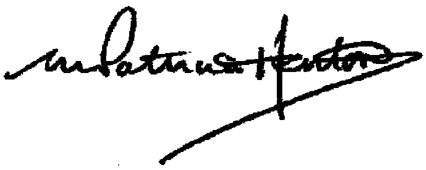
The alternative is to use reusable nappies. This reduces demands on landfill but reusable nappies impact on the environment in other ways such as the water and energy we use in washing and drying them. Both approaches therefore create their own environmental impacts.

This study reported on the way people used the leading types of both disposable and reusable nappies in 2002/3. As new products come onto the market place we will update this study and already plan to review the next generation of nappies. We expect those developing these products to use this study to shape more sustainable designs of nappies.

These are steps forward but we still need to tackle the volume of disposable products that go to landfill. If we take the Government's most optimistic forecasts we will still be landfilling over 350,000 tonnes of disposable nappies. This is at a time when we aim to reduce the volume of biodegradable waste going to landfill and to deliver more sustainable waste management. Therefore we want the main manufacturers of disposable nappies to work with us to find ways to reduce the volumes that go to landfill.

We also look to reusable nappy manufacturers to help parents review the way they launder and dry reusable products to reduce their water and energy impacts.

This LCA study provides the framework against which we can judge the success or failure of actions to reduce the impacts of reusable and disposable nappies. Further information on this study and on how you can reduce environmental impacts from the use of reusable and disposable nappies and related products is on our website at www.environment-agency.gov.uk



Tricia Henton Director of Environmental Protection

Executive Summary

In recent years, there has been considerable debate over the relative environmental performance of reusable (cloth) nappies and disposable nappies. While many people intuitively think that reusable nappies are better for the environment, disposable nappies account for some 95 per cent of the market and around 2.5 billion disposable nappies are sold in the UK each year.

The environmental impacts of different nappy types have been investigated in numerous studies. However, these studies have been limited in their accuracy or in their scope and have often been carried out by, or on behalf of, an organisation with a vested interest in the study results.

In 2001, the Environment Agency commissioned the environmental consultancy Environmental Resources Management Limited (ERM) to provide an independent and objective environmental life cycle assessment of nappy use in the UK. Life cycle assessment (LCA) is a technique used to assess environmental performance over the entire life cycle, from raw material extraction through to product manufacture, use and final disposal.

The study reported here complies with the latest methods laid down in international standards (ISO14040).

Study aims

The aim of the LCA study was to assess the life cycle environmental impacts associated with using disposable nappies and reusable nappies in the UK for 2001-2002. Three different nappy types were assessed:

- disposable nappies;
- home laundered flat cloth nappies; and
- commercially laundered prefolded cloth nappies delivered to the home.

The systems studied

To compare the nappies fairly, the study considered the environmental impacts associated with an average child wearing nappies during the first two and a half years of its life.

For each nappy type studied, all the materials, chemicals and energy consumed during nappy manufacture, use and disposal, and all the emissions to the environment were identified. All these 'flows' were quantified and traced back to the extraction of raw materials that were required to supply them. For example, polymer materials used in disposable nappies were linked to the impacts associated with crude oil extraction and the flows associated with the fluff pulp used in disposables were traced back to paper and forest growth. For cloth nappies, the flows were traced back to cotton growth and production. All transport steps have been included.

The environmental impact categories assessed were those agreed by the project board: resource depletion; climate change; ozone depletion; human toxicity; acidification; fresh-water aquatic toxicity; terrestrial toxicity; photochemical oxidant formation (low level smog) and nutrification of fresh water (eutrophication). These environmental impacts were calculated for an average nappy system in each case. The study therefore excluded impacts such as noise, biodiversity and the amount of land used by each system.

The total flows of each substance were compiled for each stage of the life cycle and used to assess the environmental impacts of each system. For example, flows of methane, carbon dioxide and other greenhouse gases were aggregated for each system in total. Internationally agreed equivalents that quantify the relative global warming effect of each gas were then used to assess the overall global warming impact of each nappy system. *Figure 1* shows the system that was studied for commercially laundered cloth nappies.

For the three nappy systems, manufacturers provided data for their production processes. Commercial laundries also supplied data. Published excreta data was used for the contents of used nappies. Data on the numbers of different nappies in use and how they were washed etc. were estimated from surveys undertaken for the Environment Agency (1). Published life cycle inventory data were used to describe commodity material and energy inputs to the stages.

Sensitivity analyses were conducted for the following key areas of uncertainty:

- reusable nappy manufacture;
- aquatic toxicity impact method;
- drying methods for reusable nappies; and
- how excreta were disposed of.

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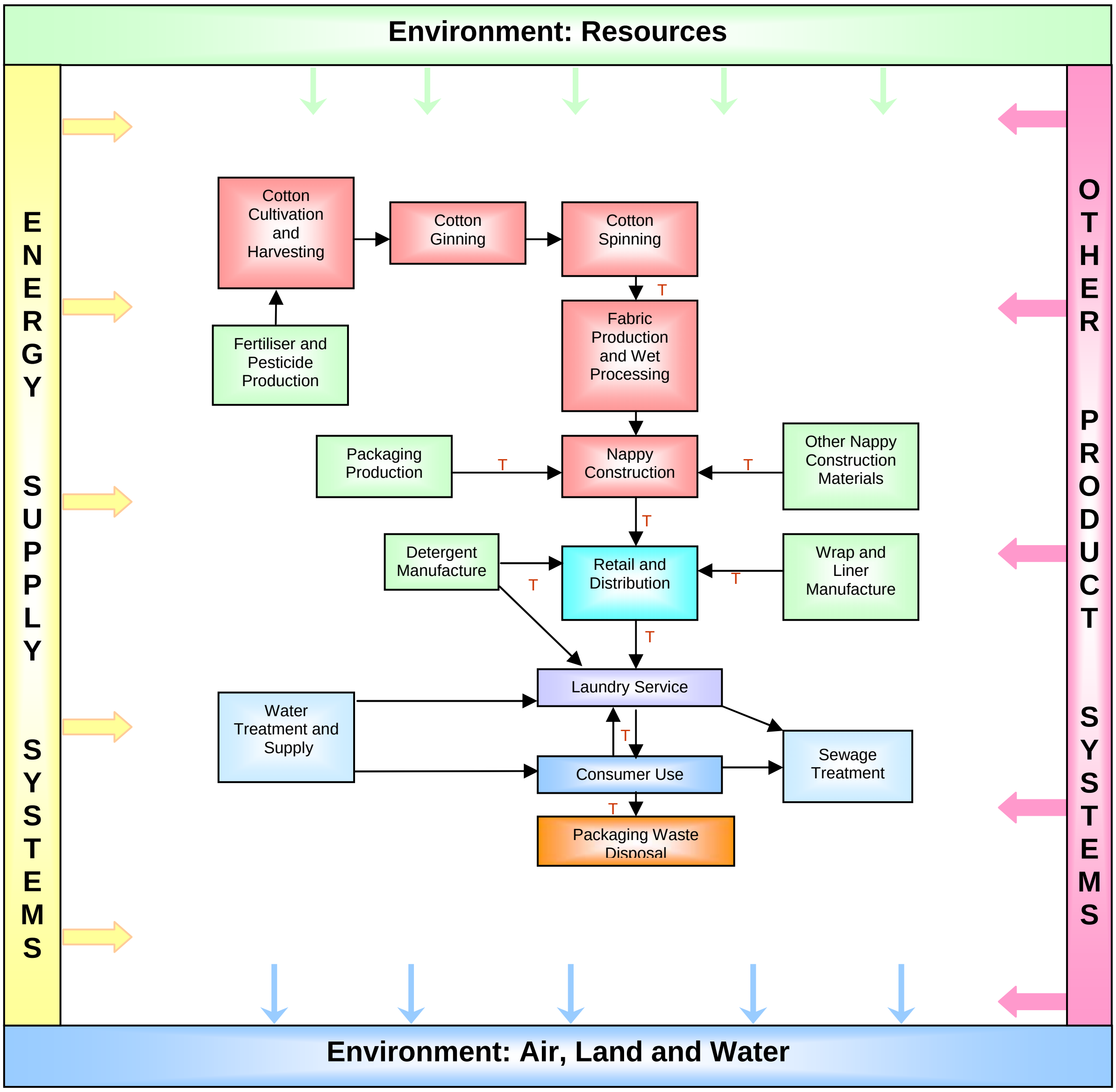
(1) Environment Agency, 2004 *Time to change? A study of parental. habits in the use of disposable and reusable nappies*. Environment Agency.

Figure 1 Commercially laundered cloth nappies



Conclusions

For the three nappy systems studied, there was no significant difference between any of the environmental impacts – that is, overall no system clearly had a better or worse environmental performance, although the life cycle stages that are the main source for these impacts are different for each system.

The study was supported by a stakeholder group representing the interested parties and is the most comprehensive, independent study of its kind. It should be used as the basis for any further studies comparing the impacts of different types of disposable or reusable nappies.

The most significant environmental impacts for all three nappy systems were on resource depletion, acidification and global warming. For one child, over two and a half years, these impacts are roughly comparable with driving a car between 1300 and 2200 miles.

The study has been critically reviewed by an external expert appointed by the Environment Agency. The review and how its findings were addressed is included in the report.

Contents

1 Introduction

1.1 Project background

There has been considerable debate about the relative environmental impacts of reusable and disposable nappies, and a number of life cycle assessment (LCA) studies have been carried out on this topic since the mid-1970s. These predate the publication of ISO14040; the International Standard for LCA. Many of the studies conform to the principles of ISO 14040, but it is generally felt that they do not represent the present UK situation due to the age of the studies and developments in the design, manufacture and use of both disposable and reusable nappies.

The Environment Agency is an independent organisation and has commissioned this LCA study to provide an accurate and objective assessment of the environmental impacts of the production, use and disposal of reusable and disposable nappy systems for the UK as a whole.

Over the last two decades, disposable and reusable nappy systems have been subject to numerous life cycle studies (see *Section 11.1* for a list of previous studies). Since they were conducted, ISO guidance has been published and new methodologies for impact assessment have been developed. Previous studies have been limited in their scope, both in the life cycle stages addressed and in the environmental issues assessed; the majority being limited to inventory analysis or analysis of specific burdens and not including a full range of environmental impacts.

This study does not assess individual brands.

The specific objectives of the project, specified by the Environment Agency, were:

- to compile a detailed life cycle inventory of the environmental burdens associated with the production, use and disposal of reusable and disposable nappies, considering various options for cleaning reusable nappies, and for disposing of disposable nappies;

- to use the life cycle inventory data to compare the potential environmental impacts arising from reusable and disposable nappies under the various scenarios considered; and

- to compare the results of the study with other key life cycle studies in this area and to identify the main reasons for any significant differences(2).

(2) This objective was considered superfluous due to the developments in LCA methodology, with nappies themselves and because the study is UK specific.

1.2 Life Cycle Assessment

The international standard for Life Cycle Assessment, ISO14040 (ISO, 2000), states that: *"LCA is a technique for assessing the environmental. aspects and potential. impacts associated with a product by:*

- *compiling an inventory of relevant inputs and outputs of a product system;*
- *evaluating the potential. environmental. impacts associated with those inputs and outputs; and*
- *interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study."*

LCA studies the environmental aspects and potential impacts throughout a product's life (i.e. from cradle to grave), from raw material acquisition through production, use and disposal. The general impacts needing consideration include resource use, human health, and ecological consequences.

The key elements of an LCA are:

- goal and scope;
- life cycle inventory analysis;
- life cycle impact assessment;
- life cycle interpretation;
- reporting; and
- critical review.

1.3 About children and nappies

Nappies are used to absorb and contain excreta produced by small children. The nappies that are used today in the UK fall into two distinct groups, disposables and reusables. These two forms, although fulfilling essentially the same function, are fundamentally different in nature and in use. Disposable nappies are single use items with no requirement for folding/preparation and no need for washing. Once used, the nappies containing excreta are generally thrown away with other household waste. Reusables are generally made of cotton cloth and are laundered and re-used many times. Excreta from these is predominately treated by the sewerage system.

It is in the first 2.5 years of life that babies are heavily dependant on nappies. After this period, children are generally less dependent on nappies due to potty training, with nappies being used mostly at night, if at all.

1.3.1 Excreta volumes

By 2.5 years, approximately 90 per cent of girls and 75 per cent of boys have complete bladder control (Stoppard, 1990). The average child will stay dry at night at 33 months (normal range 18 months to 8 years) (Green, 1998). During the first 2.5 years, according to Geigy *et al.* (1981), approximately 254 litres of urine and 98 kg of faecal matter are produced (Lenter, 1981), see *Table 1.1* and *Table 1.2*. Geigy *et al.* is a comprehensive publication in terms of volumes, composition and referencing.

Forfar and Arneil's Textbook of Pediatrics (1998), although not as comprehensive in its references as Geigy, suggests a range in urine volume of approximately 409 to 506 litres, and a range in faecal mass of 6.9 to 48.4 kg over 2.5 year period, see *Table 1.5, Table 1.6, Table1.7* and *Table1.8*. An alternative data set published by Goellner *et al.* (1981) suggests that 633 litres of urine are produced during the first 2.5 years, see *Table 1.3* and *Table 1.4*. Potty training is a variable that is difficult to include in the study, as it is extremely child dependent. Potty training will affect the use of nappies by a child and the disposal routes for excreta.

There is limited scientific literature regarding the excreta produced by children. Although quantities are of interest, in terms of the environment, composition (see *Table 1.9, Table 1.10, Table 1.11* and *Table 1.12*) and destination are likely to be of more significance.

If we use the Geigy data, in 2001-2002, 172,000 tonnes of urine and 66,000 tonnes of faecal matter would be produced by nappy wearing children (1.69 million children). If we use the Forfar data, in 2001-2002, 276,000 to 342,000 tonnes of urine would be produced by nappy wearing children.

There are other differences between the data from Geigy, Forfar and Goellner. The Geigy data includes urine, faeces and composition data, unlike Goellner, which addresses only urine volume. The Forfar data addresses urine and faeces volume, but includes more limited composition data. The Forfar faeces data is more limited than Geigy, though the data is from the same source. The Geigy faeces data seems to be the most comprehensive.

In this study, the volume of excreta generated is varied to reflect the range in the generation rates and the difference in the excreta that is captured within nappy systems. Two scenarios were analysed, one using Geigy data and the other using a mixture of Forfar data for urine and Geigy data for faeces.

Table 1.1 Urine production per child from Geigy

Age of child	Urinary volume rate ($mld^{-1}kg^{-1}$)	Total volume for period* (litres)
0-6 months	34	32.4
6–12 months	29	45.6
12-24 months	25	100.5
24-30 months	33	75.8
TOTAL		**254.3**

Source: Lenter, 1981

* Calculated using NCHS/WHO baby growth charts (50th percentile), see *Figure* 1.1.

Table 1.2 Faeces production per child from Geigy

Age of child	Faeces mass rate (gd^{-1})	Total mass for period (kg)
0-3 months	83	7.6
3 months to 2.5 years	110	90.3
TOTAL		**97.9**

Source: Lenter, 1981

Table 1.3 Urine production per child from Goellner

Age of child	Total volume for period* (litres)
0-6 months	81.8
6–12 months	116.5
12-24 months	293.6
24-30 months	141.7
TOTAL	**633.5**

Source: Goellner *et al.,* 1981
* Calculated using NCHS/WHO baby growth charts (50^{th} percentile), see *Figure* 1.1.

Table 1.4 Urine production rate per child from Goellner

Age of child	Urinary volume rate ($mld^{-1}kg^{-1}$)
0-1 months	106.6
1–2 months	110.7
2-4 months	85.2
4-6 months	73.3
6-12 months	74.1
12-18 months	80.6
18-24 months	66.2
24-32 months	61.7

Source: Goellner *et al.,* 1981

Table 1.5 Urine production per child from Forfar

Age of child	Minimum total volume for period (litres)	Midpoint total volume for period (litres)	Maximum total volume for period (litres)
0-6 months	62	74	86
6–12 months	73	82	91
12-24 months	183	201	219
24-30 months	91	100	110
TOTAL	**409**	**457**	**506**

Source: Campbell and McIntosh, 1998

Table 1.6 Urine production rate per child from Forfar

Age of child	Minimum urinary volume rate (mld^{-1})	Maximum urinary volume rate (mld^{-1})
1st and 2nd day	15	60
3-10 days	50	300
10-60 days	250	450
2-12 months	400	500
12-36 months	500	600

Source: Campbell and McIntosh, 1998

Table1.7 Faeces production per child from Forfar

Age of child	Minimum total mass for period (kg)	Midpoint total mass for period (kg)	Maximum total mass for period (kg)
0-2 months	0.9	1.7	2.4
2-30 months	6.0	26.0	46.0
TOTAL	**6.9**	**27.6**	**48.4**

Source: Campbell and McIntosh, 1998

Table1.8 Faeces production rate per child from Forfar

Age of child	Minimum total mass for period (gd^{-1})	Maximum total mass for period (gd^{-1})	Comment
Newborn	15	25	Breast-milk fed
Newborn	30	40	Cows' milk fed
2 months - 6 years	7	54	-

Source: Campbell and McIntosh, 1998

Table 1.9 Forfar urine composition data for the first 2.5 years of a child's life

Substance	Minimum total mass for period (kg)	Midpoint total mass for period (kg)	Maximum total mass for period (kg)
Ammonia	0.0782	0.1203	0.162
Calcium*	0	0.1768	0.354
Chloride*	0	0.6269	1.254
Copper*	0	0.0000183	0.0000365
Lead	0.00000137	0.0000107	0.0000201
Magnesium*	0	0.0046	0.00913
Nitrogen	0.0301	0.0526	0.0752
Phosphorous*	0	0.0913	0.183
Potassium*	0	0.3457	0.691
Sodium*	0	0.3761	0.752
Water**	408.57	455.56	502.54

Source: Campbell and McIntosh, 1998

*For these elements no minimum value was quoted, we have assumed a minimum of zero. Forfar data only provided maximum quantity in these cases.
** The remainder of the total volume is assumed to be water.

Table 1.10 Forfar faeces composition data for the first 2.5 years of a child's life

Substance	Minimum total mass for period (kg)	Midpoint total mass for period (kg)	Maximum total mass for period (kg)
Calcium	0.183	0.228	0.274
Copper**	0	0.000316	0.00063158
Iron	0.000720	0.000783	0.000846
Magnesium*	0.0154	0.0308	0.0461
Nitrogen*	0.146	0.146***	0.146***
Phosphorous*	0.143	0.160	0.176
Potassium	0.00323	0.03405	0.09656
Sodium	0.0142	0.0864	0.203
Water****	5.64	23.22	41.64

Source: Campbell and McIntosh, 1998
* Quantity represents faeces for a child. This data is based on an adult composition that has been multiplied by the ratio of baby body weight to adult body weight. Average adult weight was assumed to be 70 kg and average baby weight to be 9.69 kg, using baby growth charts (50th percentile), see *Figure 1.1.*
** For copper no minimum value was quoted, a minimum of zero was assumed.
*** Forfar data only presented a minimum total mass for the period in these cases.
**** Water content is based on Forfar data representing a child aged 3 months to 6 years.

Table 1.11 Geigy urine composition data for the first 2.5 years of a child's life

Substance	Quantity	Unit
Ammonia	0.00000739	kg
Antimony*	0.000000189	kg
Arsenic*	0.00000594	kg
Boron*	0.000126	kg
Bromide*	0.000467	kg
Cadmium*	0.00000027	kg
Caesium*	0.00000164	kg
Calcium	0.0319	kg
Chloride	1.018	kg
Chromium	0.00000539	kg
Cobalt	0.00000009	kg
Copper	0.0000275	kg
Inorganic sulphate*	0.148	kg
Iodide	0.000548	kg
Iron*	0.0000111	kg
Lead	0.0000164	kg
Lithium*	0.000101	kg
Magnesium	0.0247	kg
Manganese*	0.0000137	kg

Substance	Quantity	Unit
Mercury	0.000000126	kg
Molybdenum*	0.0000102	kg
Nickel*	0.00000033	kg
Nitrogen	1.606	kg
Phosphate	1.733	kg
Potassium	1.147	kg
Rubidium*	0.000303	kg
Scandium*	0.00000000922	kg
Selenium*	0.00000379	kg
Silver*	0.0000000695	kg
Sodium	0.565	kg
Strontium	0.0000154	kg
Sulphur*	0.167	kg
Tungsten*	0.00000404	kg
Urea*	2.602	kg
Water**	245.3	kg
Zinc	0.000347	kg
Total	**254.3**	**kg**

Source: Lenter, 1981
* Quantity represents urine for a child. This data is based on an adult composition that has been multiplied by the ratio of baby body weight to adult body weight. Average adult weight was assumed to be 70 kg and average baby weight to be 9.69 kg, using baby growth charts (50th percentile), see *Figure 1.1.*
** The remainder of the total volume is assumed to be water.

Table 1.12 Geigy faeces composition data for the first 2.5 years of a child's life

Substance	Quantity	Unit
Ammonia*	0.0523	kg
Bicarbonate	0.227	kg
Cadmium*	0.0000202	kg
Calcium*	0.0846	kg
Chromium*	0.00000758	kg
Cobalt*	0.00000505	kg
Copper*	0.000248	kg
Dry mass	3.833	kg
Fluoride	0.000265	kg
Iodine*	0.00000207	kg
Iron*	0.00243	kg
Lead	0.0000164	kg
Magnesium*	0.0152	kg
Manganese*	0.000466	kg
Molybdenum*	0.0000158	kg
Nickel*	0.0000328	kg
Nitrogen	0.548	kg
Other	8.654	kg
Phosphorous	0.0159	kg
Potassium*	0.0556	kg
Sodium*	0.0189	kg

Substance	Quantity	Unit
Tin*	0.000505	kg
Titanium*	0.0000366	kg
Vanadium*	0.000253	kg
Water**	84.39	kg
Zinc*	0.00134	kg
Total	**97.9**	**kg**

Source: Lenter, 1981
* Quantity represents urine for a child. This data is based on an adult composition that has been multiplied by the ratio of baby body weight to adult body weight. Average adult weight was assumed to be 70 kg and average baby weight to be 9.69 kg, using baby growth charts (50th percentile), see *Figure 1.1.*
** The remainder of the total volume is assumed to be water.

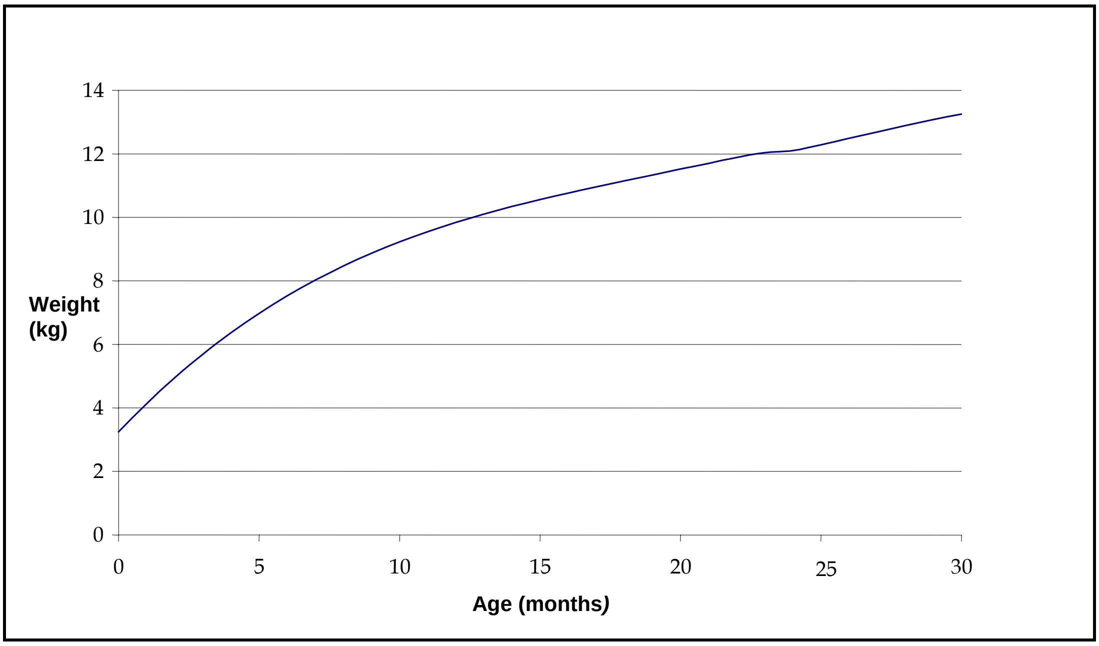


Figure 1.1 Baby growth chart (50th percentile)

Generated from: *NCHS/WHO reference data for the weight and height of children.* (www document) http://www.who.int/nutgrowthdb/reference.html

1.3.2 Disposables

Disposables can be divided into the following categories:

- **the super-absorbent nappy (ultras)**; and
- **the basic nappy** (no super-absorbent polymer, relying on fluff pulp for absorbency).

Ultras are the dominant type of disposable nappy on the market in terms of sales, accounting for 94 per cent of the market in 1999 (MINTEL, 2000). Disposable nappies are sold in a number of sizes for different weights of babies, the most popular size range being for babies between 20 and 40 lbs in weight (MINTEL, 2000). The basic nappy is considered a niche market as none of the major manufacturers produce these nappies and it is therefore not representative of the market.

1.3.3 Reusables

Today's reusable and washable cotton nappies come in a variety of forms and are nearly all fitted and fastened with poppers or velcro straps instead of pins. There are many different reusable nappy systems, which can be divided into the following broad categories:

- **all-in-ones -** shaped, fitted nappies with velcro or popper fastenings, which have a built-in waterproof cover. No folding or pinning is required;

- **shaped nappies -** similar to all-in-ones, but *without* the built-in waterproof cover which is purchased separately (wraps/pants). These do not require folding. They are fastened by velcro or poppers; and

- **flat nappies - terry/wrap around/prefold -** require folding and a separate waterproof wrap/pant, with fasteners used in some cases.

All-in-one nappies are similar in appearance to disposable nappies, comprising an absorbent layer with an integral waterproof wrap/pant. They are usually fastened with velcro. They are slower to dry because the waterproof layer reduces drying efficiency.

Shaped nappies are generally considered easier to use than flat/prefold nappies, in that no folding is required. Some have velcro or popper fastenings, and others rely on the wrap/pant to hold them in place.

Terry nappies are made of 100 per cent terry towelling squares. Terries can be folded in a number of ways to suit different size babies. Terries are considered to be quick drying.

Prefold nappies are made from woven cotton and consist of a large rectangle of fabric that has been folded and stitched into three panels, the centre panel being thicker than the two outer panels. Prefolds are considered quick drying.

Traditionally, terries were fastened with safety pins, but plastic grips/wraps/pants are now generally used to fasten terries. Prefold nappies are designed to be used without fasteners and are held in place by the wrap/pants.

1.3.3.1 Wraps/Pants and liners

Wraps/pants are made of a number of different materials and combinations of materials, such as: nylon; polyvinyl chloride (PVC); ethylene vinyl acetate (EVA); polyester; cotton; wool; hemp; and polyurethanes. Wraps/pants are not considered as durable to washing, drying and wear as nappies, and hence they may need to be replaced at regular intervals. Wear is dependent on the care they receive. Following manufacturers' care guidance is essential for maximising their life. Some wraps/pants are adjustable and are designed for use from birth to potty; others are replaced when necessary to fit a growing baby. Generally, three different sizes will be needed over the period of a baby's use of nappies.

In combination with the nappies and wraps/pants, parents can use liners and booster pads to improve performance and ease of cleaning. Liners are used to provide a drier layer between the baby and the absorbent nappy, to assist in containment of faecal matter and for ease of cleaning. Liners come in reusable or disposable forms. Materials that are used include paper, polypropylene, fleece and silk. Depending on circumstances and on the baby, it is sometimes necessary to boost the performance of a nappy by doubling up nappies to increase absorbency or to use specifically manufactured booster pads.

1.3.4 Market share

There are three main manufacturers and suppliers of disposable nappies in the UK: Procter & Gamble; Kimberly Clark; and SCA Hygiene. Together with other smaller brands of disposable nappies, the total number of disposables sold annually in the UK is approximately 2.47 billion (Absorbent Hygiene Products Manufacturers Association (AHPMA)). At an average weight of 44.6 g (UK average weight, 2001), this would equate to a total sold of approximately 110,000 tonnes per annum that will become waste after use (not including excreta). Together, Procter & Gamble and Kimberly Clark account for approximately 75 per cent of the market and SCA account for most of the rest (MINTEL, 2000). Both Kimberly Clark and Procter & Gamble manufacture disposable nappies in the UK, whilst SCA manufactures nappies on mainland Europe.

Although no published market data has been found, various informed views refer to a market penetration for reusables of between 5 per cent and 15 per cent of babies (Environment Agency, 2004). However, recent research by the Environment Agency determined market share to be less than 4 per cent (Environment Agency, 2004). There has been an expansion in the number of suppliers in the UK over the last few years, which may suggest the market share is growing.

The major retail routes for reusables appear to be through high street shops, mail order, via the internet and from nappy sales agents, while a nappy home delivery and collection service is provided by nappy laundries (effectively nappies are rented on a weekly basis).

Commercial nappy services that involve a centralised laundry are gaining in popularity and coverage in the UK. A bin is provided by the laundry service for the collection of dirty nappies and for the delivery of washed and dried nappies on assigned days.

1.4 Previous studies

Previous studies provide us with an indication of the significance of the various life cycle stages and the critical issues that affect the results of an LCA study of nappies.

For both disposable and reusable nappies, raw material production and manufacturing have been identified as significant aspects of the life cycle. For disposables, it has been suggested that end of life is significant. For reusables, the use stage has been identified as significant due to the energy, detergent and water requirements of laundering operations and the subsequent treatment of wastewater.

Omissions from previous studies include the environmental impacts of waste disposal, both solid and liquid wastes, and retail and consumer transport steps.

The main issues that have been identified from previous studies as having a significant influence on results are:

- the daily number of changes for each system;
- the number of reusable nappies required over a given period;
- consumer care parameters (washing temperatures/wash loads/wash frequency/drying method/detergent loading etc.);
- reusable nappies are sometimes doubled up to provide sufficient absorbency; and
- reuse assumptions for reusables once they are no longer required by the child.

Previous studies have provided data regarding the daily consumption of disposable and reusable nappies during the period in which a child is in nappies. The number of disposable nappies used per day in the previous studies (see list in *Section 4.1*) ranged from 4 to 6.4 as an average for the 2.5 year period. The corresponding range for reusable nappies is 5.8 to 12.2.

When determining the number of nappy changes per day, a number of different factors must be taken into account. The age of the child will be a key determinant of the number of changes, as a younger child is generally changed more frequently than an older child. Disposable nappies, due to the absorbency of fluff pulp and sodium polyacrylate (super absorbent polymer or SAP) can contain large volumes of liquid. This absorbency is reflected in the lower change frequency that is reported for disposable systems when compared with reusable systems. To increase absorbency at night time, a reusable nappy may be used with a booster pad or another nappy, although this is dependant on the type of reusable nappy. Consequently, the total number of nappies used per day may be lower for the disposable system.

In previous studies, the manufacture of disposables is well reported and quantified. However, there is a lack of data regarding cotton production and reusable nappy manufacturing. For disposable nappies, there is a lack of data describing the behaviour of disposable nappies and their contents when they are disposed. For reusable nappies, there is a lack of data regarding the management of the excreta at waste water treatment plants.

This study aimed to obtain data to fill these gaps and to obtain new and up to date information regarding consumer use characteristics in the UK. The study also addresses, through sensitivity analysis, critical assumptions for which data are not available. The study includes all life cycle stages and conforms to the international standards for LCA.

2 Goal of the study

The international standard ISO 14041 (ISO, 1998) requires that the goal of an LCA study shall unambiguously state the intended application, the reasons for carrying out the study and the intended audience.

The goal of this study is to assess the potential life cycle environmental impacts associated with using disposable and reusable nappies in the UK in 2001-2002.

The goal of the study has been split into the following objectives:

- to compile a detailed life cycle inventory of the environmental burdens associated with the production, use and disposal of reusable and disposable nappies, considering various options for cleaning of reusable nappies, and disposal options for disposable nappies; and
- to use the life cycle inventory data to compare the potential environmental impacts arising from reusable and disposable nappies under the various scenarios considered.

The LCA study will be used to report the environmental aspects associated with the life cycles of reusable and disposable nappy systems to the Environment Agency and to a wider audience. As this study will be used externally, it has undergone critical review by an external reviewer in accordance with ISO14040.

3 Scope

The scope of the study addresses the following items:

- the functions of the product systems;
- the functional unit;
- the product systems to be studied;
- the product system boundaries;
- allocation procedures;
- types of impact and methodology of impact assessment, and subsequent interpretation to be used;
- data requirements;
- assumptions;
- limitations;
- initial data quality requirements;
- type of critical review; and
- type and format of the report required for the study.

3.1 Functional unit

Previous life cycle studies that have compared the environmental profiles of disposable and reusable nappies have used various functional units. Some of these have defined a time period while others have chosen to look at a specific number of nappy changes.

The function that is appropriate to the goals of the study is defined as "*the use of nappies during the first 2.5 years of a child's life, in the UK, for the period 2001-2002*". This functional unit will result in a specific quantity of disposable and reusable nappies used within the time period of 2.5 years.

The reason for focussing on the first 2.5 years is that by this point nappy use is tailing off, and beyond this point nappy use varies considerably between individuals. This approach takes into account the range of sizes and fluctuations in user patterns that may occur during the total period a child is in nappies.

This functional unit was agreed by the Project Advisory Board.

The Environment Agency commissioned surveys of both disposable and reusable nappy use. These surveys (Environment Agency, 2004) determined that the average child is out of nappies at 2 years 2 months (same for both type of nappy) and that after 2.5 years 95 per cent of all children are out of nappies. The study reflects the first 2.5 years of an average child's life in the UK. Therefore, the systems modelled take account of those children who stop using nappies earlier than 2.5 years, see *Table 3.1.*

The time children spend in nappies is specific to the individual, but the majority of children have undergone toilet training under the age of 2.5 years. Although they may still use training pants or overnight nappies for a significant period beyond this point, the use of these types of products is outside the scope of this study.

Table 3.1 Children wearing nappies by child age (all types of nappy)

Age of child	Children wearing nappies (%)	Children not wearing nappies (%)
up to 6 months	100.0%	0.0%
6 to 12 months	95.7%	4.3%
12 to 18 months	82.8%	17.2%
18 to 24 months	45.6%	54.4%
24 to 30 months	17.6%	82.4%
30 to 36 months	4.8%	95.2%
36 to 42 months	1.8%	98.2%
42 to 48 months	0.4%	99.6%
48 to 54 months	0.1%	99.9%
54 to 60 months	0.1%	99.9%
60 to 66 months	0.1%	99.9%

Source: The Environment Agency surveys (Environment Agency, 2004)
Note: The surveys showed that there is no difference in age out of nappies between children using reusable or disposable nappies. The figures in the table are for disposable nappies for which there were more results but were applied to all children.

3.2 Product systems and system boundaries

The system boundaries define the life cycle stages and unit processes to be studied and the environmental releases (e.g. carbon dioxide, methane etc.) and inputs (e.g. coal reserves, iron ore etc.) to be included in the evaluation. System boundaries should be defined in such a manner that the inputs and outputs from the system are elemental flows (3).

The aim of the study is to include all the significant processes, tracing material and energy flows to the point where material and energy are extracted or emitted to the natural environment.

The objective of the project was to assess a typical disposable and a typical re-usable, taking into account 'all in one' type nappies and the flat nappies with a wrap/pant.

(3) An elemental flow is material or energy entering the system being studied, which has been drawn from the environment without previous human transformation, or it is a material or energy leaving the system being studied, which is discarded into the environment.

It was the ambition of this study to be representative of the UK situation, in 2001-2002, and to reflect the nappies that are used in the UK. The study reflected the UK situation by assessing the average nappy systems in use in 2001-2002. By average, we mean in terms of weight, composition, manufacturing processes and use characteristics.

This study addressed flows to and from the environment for each life cycle stage. However the study excluded the environmental implications of land occupation and use, for example, the implications of alternative land use and the effects of land use changes were excluded. The systems assessed were considered to be steady state.

3.2.1 Average systems

To study average systems, a substantial amount of data and statistics for nappies used in the UK was collected to ensure that the study was representative of UK usage.

The main disposable nappies in the UK are very similar. Due to their similarities in terms of composition and use, it was practicable and reasonable to assess an average disposable nappy sold in the UK. A calculated average nappy, in terms of composition and weight sold in the UK, in a particular year, can be assumed to be an accurate representation of the nappies used by a child over its first 2.5 years of life. A methodology to specify the average disposable nappy in the UK was developed by ERM and applied by the disposable nappy manufacturers. *Table 3.2* shows the results of this process.

With regard to reusables, the picture was more varied, due to the diverse range of products and combinations (wraps/pants, liners and booster pads) in use. The lack of market data and user surveys regarding popularity made it difficult to define typical systems. As a result, ERM conducted a survey of reusable sales by nappy type in the UK in order to define an average reusable nappy for this study. The survey ascertained that the most popular type of nappy in the UK is the terry nappy, and the most popular wrap/pant is the plastic waterproof wrap/pant. Terry nappies accounted for approximately 37 per cent of reusable nappy sales, with prefolds totalling 25 per cent. Shaped and 'all-in-ones' had similar sales of approximately 20 per cent each.

The Environment Agency surveys (Environment Agency, 2004) showed that terry nappies were the most popular and prefold nappies a close second amongst the survey population. 'All-in-ones' were by far the least popular.

On the basis of these surveys, it was agreed that both terry and prefold nappy systems should be studied.

The surveys undertaken on behalf of the Environment Agency also provided data on how nappies are used and cared for, the use of liners and booster pads, the number of changes and the types of wraps/pants and waterproof pants used.

The survey identified that terry users own on average 31.2 nappies at any one time. However, the survey failed to ascertain how many were purchased in total, by users, over the 2.5 years. We have assumed that the maximum owned in any one six month period reflects the total purchased. This equated to 47.5 nappies. This figure is not considered to be robust due to the limited number of data points, but it is believed to be reasonable when one considers that 31.2 terry nappies are owned at any one time. The majority of users do not use booster pads but do use disposable liners. 88 per cent of reusable nappy users use disposables as well as reusables. The most popular wraps/pants amongst terry nappy users were PVC wraps.

The nappy systems assessed include all life cycle stages. All energy and materials used were traced back to the extraction of resources. Emissions from each life cycle stage were quantified. Waste management processes (landfilling, incineration and waste water treatment) were also assessed.

The Environment Agency surveys of consumer use have been used to define the nappy systems modelled (Environment Agency, 2004).

3.2.2 Disposable nappy system

Most of the disposable nappies that are sold in the UK are also manufactured in the UK, although several raw materials are obtained from other European countries or from North America.

Disposable nappies are based on two main materials; cellulose fibres and polymers. The core is composed of fluff pulp and SAP, which is a water absorbing polymer. The function of the core is to absorb and contain liquid excreta. The top layer, referred to as 'non-woven', is a polymer-based material with a textile structure. From the top layer, the fluids flow through a pulp-based tissue layer down to the core. Leakage is minimised by a plastic bottom layer and by elastic barriers. The nappy is prevented from falling off by rubber waist elastics and is fastened around the child's waist by non-woven based hook and loop details.

The different materials in the nappies are glued together with polymer-based adhesives. The packaging consists of polyethylene plastic bags and corrugated board boxes. Nappies are sold in different pack formats, of which the convenience pack (one week's supply), the economy pack (2 weeks' supply) and the Quattro pack (3 weeks' supply) are the most common.

Table 3.2 presents the average composition of a UK disposable nappy for 2001-2002. *Table 3.3* presents the average composition of European disposable nappy in 2000.

Table 3.2 Average UK disposable nappy composition and weight (2001-2002)

Average wt	Fluff Pulp	SAP	LDPE	PP	Elastic	Adhesives	Other
g	%	%	%	%	%	%	%
44.64	42.77	27.63	7.74	15.25	0.53	2.99	3.09

LDPE: Low Density Polyethylene
PP: Polypropylene

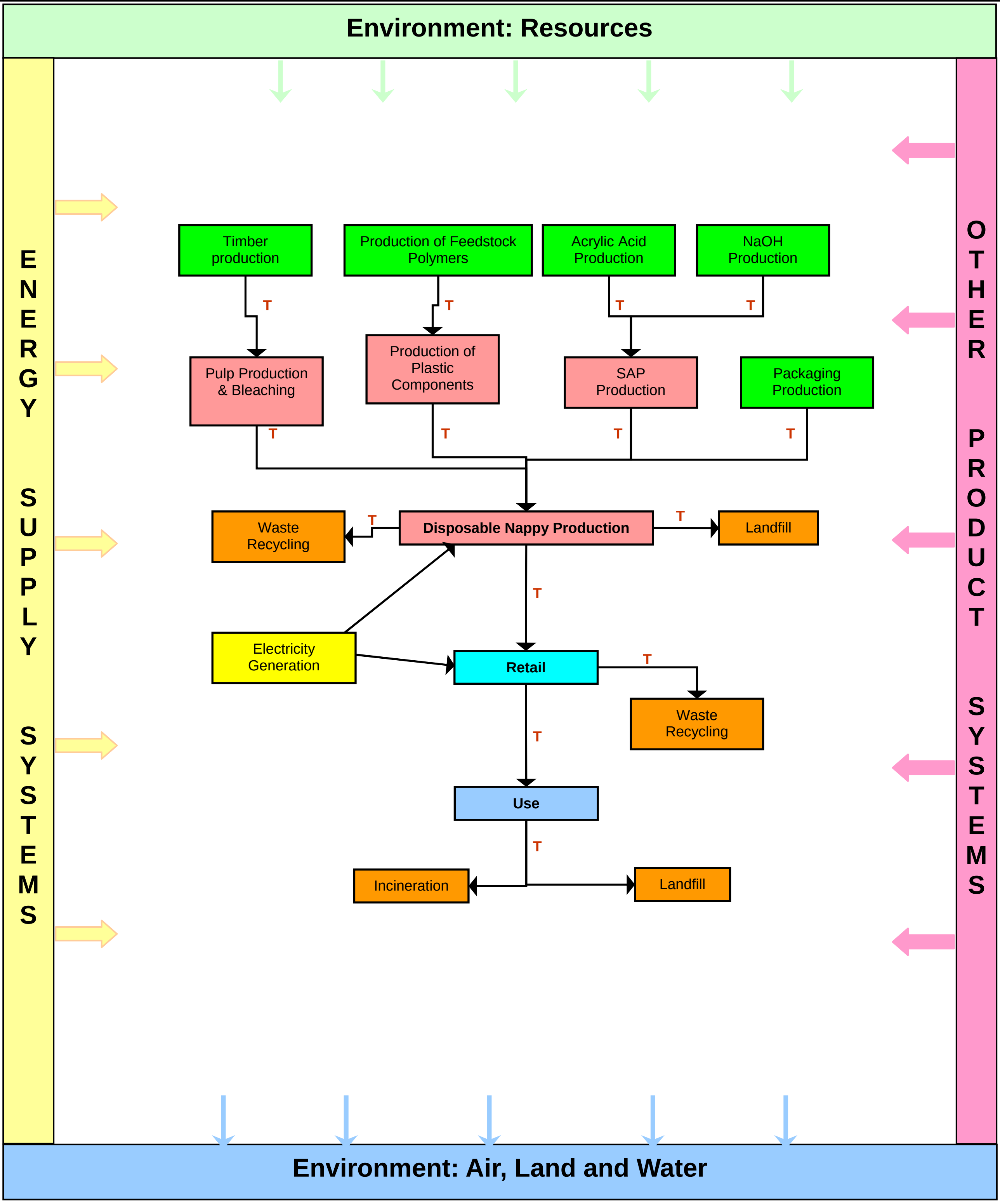
Table 3.3 Average European (UK included) disposable nappy composition (2000)

Nappy Component	Details	Composition
Core	Consists mainly of fluff pulp (43% of a nappy) and super absorbent material (27% of a nappy). Absorbance and retention of urine.	70%
Polypropylene	Polypropylene topsheet protects skin from wetness	10%
Polyethylene	Polyethylene backsheet provides leakage protection	13%
Other	Consists of tapes, elastics and adhesives	7%
TOTAL		**100%**
Average weight of a nappy		**45-50 g**

Source: EDANA, 2001.

The nappies are distributed from the manufacturers either directly to retailers (grocery/supermarket chains, independent grocers or chemists), or via distribution centres maintained by the manufacturers. Customers buy their nappies at the retailer and transport them home for use. Used nappies (containing excreta) are discarded along with other municipal waste and will later on end up disposed either to landfill or to incineration. In the UK, approximately 8 per cent of municipal waste is incinerated.

Figure 3.1 details the main life cycle stages that will be included in the life cycle of disposable nappies. Due to the complexity of the product system, it is impractical to draw a full system diagram that includes all the processes where human influence occurs, although they have been included in the study.



Note: the main transport steps (marked with a T) between processes and life cycle stages have been included in the assessment. Waste management associated with production and the supply chain has also been included in the assessment.

Figure 3.1 Outline system diagram for the disposable nappy system

3.2.3 Home laundered reusable nappy system

Figure 3.2 details the main life cycle stages that have been included in the life cycle of home laundered reusable nappies. Due to the complexity of the systems reported in the surveys, a terry system has been defined according to the dominant use characteristics identified in the surveys, this system has then been tested through a number of scenarios (developed from the survey) in sensitivity analysis.

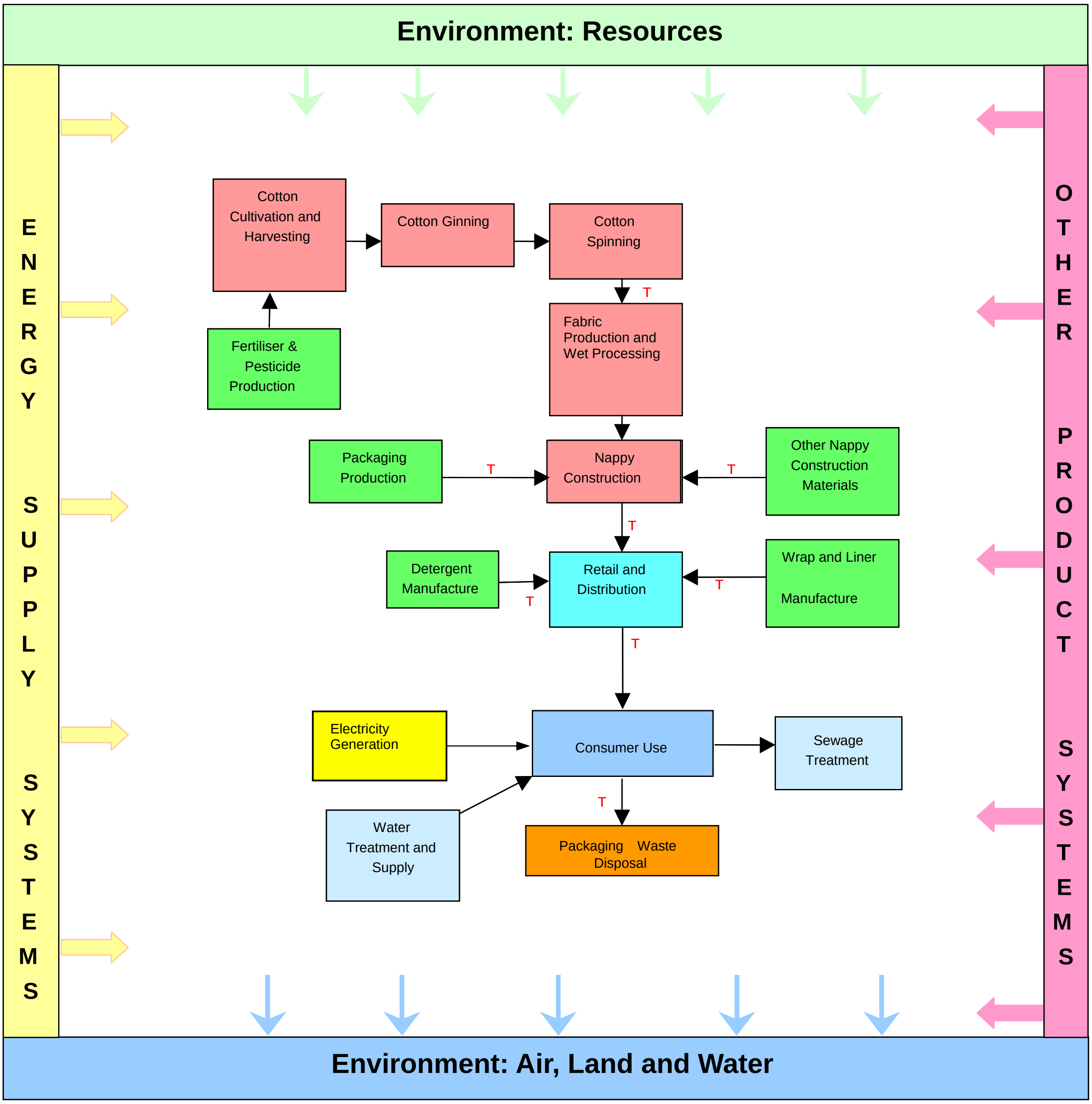
Most of the terry nappies that are sold in the UK are believed to be manufactured outside of the UK, in areas associated with cotton growing and textile production such as Pakistan, China and the USA. However, there are terry nappy manufacturers in the UK.

Cotton is a perennial crop, with mature cotton bolls harvested mechanically and transported to a ginning plant where the cotton fibre is separated and baled. The cotton bales are then transported to textile manufacturers or yarn spinning plants, where they are opened, the cotton fibre is carded and spun into yarn. The yarn is then woven into terry towelling, cut and stitched. The nappies are then packaged and dispatched to customers.

Consumers purchase the terry nappies and associated accessories, such as wraps and liners, from retail outlets such as supermarkets, high street stores, chemists and via the internet.

During use, terry nappies are generally soaked in a solution of sanitising fluid prior to washing. Nappies are washed in washing machines and either tumble dried or air dried.

The bins used for soaking nappies are commonly household buckets/bins used for other purposes. It has been decided to omit the manufacture of these bins, as their contribution is considered insignificant, particularly if they may be used for other functions.



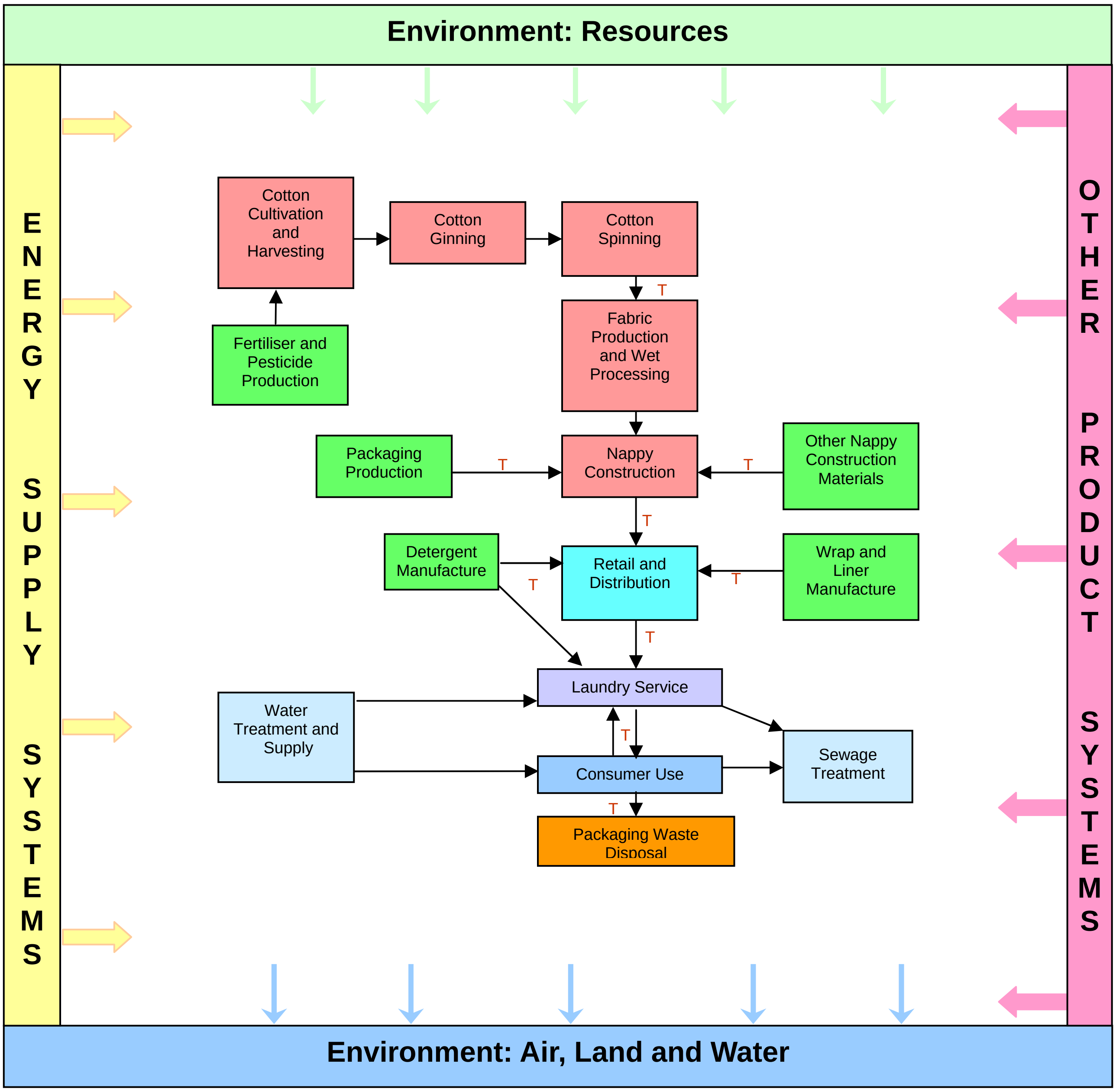
Note: the main transport steps (marked with a T) between processes and life cycle stages have been included in the assessment. Waste management associated with production and the supply chain have also been included in the assessment.

Figure 3.2 Outline system diagram for home laundered reusable nappy system`

3.2.4 Commercially laundered nappy system

Laundering services for nappies operate throughout the UK and use prefold or shaped cotton nappies. The Environment Agency surveys (Environment Agency, 2004) identified prefold nappies as dominant amongst commercial laundry users. A week's supply of nappies is delivered to the door, and at the same time the previous week's soiled nappies are collected and delivered to a laundry. Wraps/pants are cleaned in the home.

Prefold nappies are made from cotton in a similar way to terry nappies, see *Section 3.2.3*. Nappies are hired to customers. Service providers also retail liners and wraps to customers. *Figure 3.3* details the main life cycle stages that have been included in the life cycle of commercially laundered reusable nappies.



Note: the main transport steps between processes and life cycle stages have been included in the assessment. Waste disposal associated with production and the supply chain have also been included in the assessment.

Figure 3.3 Outline system diagram for commercially laundered reusable nappy system

3.3 Allocation

Some processes may yield more than one product and they may also recycle intermediate products or raw materials. When this occurs, the LCA study has to allocate material and energy flows, as well as environmental releases, to the different products in a logical and reasonable manner.

Where the need for allocation presents itself, then the inputs and outputs of the inter-related product systems have been apportioned in a manner that reflects the underlying physical relationships between them. However, there are certain circumstances where this is not appropriate or possible to do. In the study, an allocation has been conducted for retail energy use using an economic approach. Allocation methods have been documented in the inventory analysis.

3.4 Inclusions/exclusions

3.4.1 Capital equipment

All equipment necessary for any process involved in the life cycle of disposable or reusable nappies is referred to as capital equipment. Examples of capital equipment are:

- washing machines;
- harvesting/forestry machines;
- factory buildings;
- process equipment, e.g. boilers, fans, pumps, pipes etc.; and
- vehicles.

To satisfy the general belief that the production of capital equipment is likely to be insignificant, some previous life cycle studies were consulted. The findings were as follows.

- In 1992, the PA Consulting Group showed, in a life cycle assessment study on washing machines, that the energy consumption of a washing machine is approximately 23 times higher during the use phase compared to the production phase (PA Consulting Group, 1992).

- A life cycle assessment on forestry harvesting machines in 2001 showed that the fossil energy consumption, and hence the global warming potential, associated with the production phase constituted approximately 2-3 per cent of the consumption during the whole life cycle (Cranab AB, 2001).

- In the LCAs performed by Volvo Trucks, the use phase of a truck contributes more than 90 per cent of the environmental burden of the whole life cycle (Volvo Trucks, 2001).

Based on the conclusions of these studies, it was decided to exclude environmental burdens associated with the production of capital equipment.

3.4.2 Workforce burdens

It is not common practice when conducting LCAs to include an assessment of human labour burdens, due to difficulties in allocation, drawing boundaries, obtaining data and differentiating between labour and capital equipment.

For product LCAs where products and production processes are similar, it is reasonable to assume that human labour is the same for each product system, in which case it is reasonable to exclude human labour from the study. This assumption needs to be tested as product systems diverge.

We have excluded human labour as being outside the scope and resources of this project.

3.4.3 Excreta

As discussed in *Section 3.1* on the functional unit, excreta must be considered within the system boundaries when comparing disposable and reusable nappy systems. The main reason for this is that both nappies and the excreta undergo completely different types of waste treatment due to the different characteristics of the systems.

Since many users of disposable nappies have chosen the products, at least partly, for convenience reasons, we believe it is reasonable to assume that all excreta will be disposed together with the nappies. Consequently, excreta will follow the household waste stream all the way from the nappy waste bin in the home to landfill and incineration facilities.

For users of commercial laundered and home laundered reusable nappies, a proportion of the excreta will be flushed down the toilet, together with soiled disposable liners, before the nappies are washed. This effluent will enter the sewerage system. The remaining excreta will enter the sewerage system through the washing machine outflow or from rinsing and soaking. Sewage treatment has been modelled on the basis of typical sewage treatment processes in the UK.

3.5 Key assumptions and limitations

All assumptions have been recorded and reported in this report. All key assumptions have been tested through sensitivity analysis, see *Section 9*. Through a review of previous studies, it has been ascertained that the number of nappy changes and consumer use characteristics are critical to the results.

3.6 Initial data requirements

In addition to collecting data describing the use and manufacture of the nappy types to be assessed, the following were identified as key elements for which inventory data are required:

- UK electricity generation (2001-2002) by type (e.g. coal, gas, nuclear, hydro, wind etc.);
- cotton growing and fabric production;
- detergent manufacture;
- water treatment;
- sewage treatment;
- waste management;
- nappy materials manufacture;
- reusable use scenarios; and
- other commodity material inputs to the systems.

3.6.1 Data quality requirements

The key requirements regarding data quality were that they were representative of nappies used in the UK in 2001-2002.

Data were collected mainly from the following sources:

- questionnaires and interviews with experts regarding the main life cycle stages;
- validated life cycle inventory databases for commodity material and energy inputs to the stages; and
- published literature describing the inputs and outputs from life cycle stages.

The data collected and used for this study have been documented and reviewed with regard to quality by ERM and the peer reviewer.

3.6.2 User surveys

Due to the lack of information regarding the use of nappies on children, the Environment Agency commissioned some questions in the National Statistics Omnibus Survey (June 2002 – February 2003) in relation to the use of reusable and disposable nappies (by children). The survey addressed the types of nappies being used, the average number of changes per day and the age at which children stop using nappies.

Insufficient users of reusable nappies were found in the Omnibus survey, so a second survey targeted at reusable nappy users was commissioned. TEST Research conducted face to face interviews (March - April 2003) with 183 parents.

The purpose of this survey was to establish the types of reusable nappies being used, how they were being used and what other products were being used in support of the nappies, i.e. wraps, booster pads, liners, detergents etc.

The survey findings have been published by the Environment Agency (Environment Agency, 2004).

3.6.3 Data for disposables

The manufacturers of disposables have supplied data describing the average composition and weight of a disposable nappy in 2001-2002, and the average manufacture of disposable nappies. In addition to this, the average weight of packaging by material type that is associated with an average nappy has also been provided.

ERM has been provided with access to the EDANA (European Disposables and Nonwovens Association) life cycle inventories for material inputs to the manufacturing processes. The EDANA database has been developed by IFEU (Institute for Energy and Environmental Research). IFEU are an internationally respected organisation in the field of LCA, and are involved in the development of LCA methodology, conducting LCAs and peer reviews of LCA studies. IFEU were commissioned by EDANA to generate life cycle inventories for all materials associated with the manufacture of disposable nappies. The inventories have been generated by collating data from the producers of nappy manufacturing materials.

The *WISARD* software (Ecobalance, 1999) and supporting literature has been used to model the disposal of disposable nappies.

3.6.4 Data for the home laundered reusable nappy system

The surveys conducted by ERM and the Environment Agency (Environment Agency, 2004) were used to define typical nappy systems. For the specified nappy types, ERM has undertaken a survey to specify the average composition and weight of a nappy and the associated wraps/pants.

To assist ERM in defining the manufacturing process for the reusable nappy system, a survey of nappy manufactures was undertaken. ERM provided questionnaires to over thirty manufacturers, and received, in return, only one complete response.

The ERM sales survey determined that the majority of reusable nappies are purchased from high street shops.

From the Environment Agency surveys, a profile of how nappies are used was generated.

ERM obtained UK data regarding sewage treatment, waste management, washing machine and tumble drier performance.

3.6.5 Commercially laundered nappy system

To assess commercially laundered nappies, we surveyed 22 laundry service providers. Four provided us with usable data regarding collection vehicles, collection distances, nappy usage and laundering activities.

3.6.6 Temporal, spatial and technological scope

The geographical coverage is defined as the use of nappies in the UK in 2001-2002. However, raw material production and some processing occurs outside of the UK. The technologies to be assessed will be representative of the product systems assessed. However, an indication of the age and classification of the technologies has been included in the study.

The geographic, temporal and technological scope of the data has been recorded.

3.7 Inventory analysis

Inventory analysis involves data collection and calculation procedures to quantify relevant inputs and outputs of a product system. For each of the nappy systems assessed, inventories of significant environmental flows to and from the environment, and internal material and energy flows, have been produced. Significance was determined by threshold (more than 1 per cent of inputs) and environmental significance (potential for harm). This has been achieved through the collection of data specific to the processes of each product system.

Data sources include both specific and representative data. It was the ambition of the LCA practitioners to collect specific data relating to the life cycle stages. However, proprietary life cycle databases have been used for common processes, materials, transport steps and electricity generation. Where data are missing, estimates based on literature and previous studies have been made.

The inventories that have been generated provide data on hundreds of internal and elemental flows for each nappy system. Summary inventory for the three systems have been provided in *Annex A*. However, based on a review of previous studies and the views of the advisory board, the following flows have been analysed in detail, for each nappy system:

- water use;
- fossil fuel use;
- solid waste (internal flow);
- COD;
- BOD;
- non-renewable CO_2 emissions;
- CH_4 emissions;
- NO
- NO_x as NO_2; and
- SO_2 emissions.

Water use has been reported in terms of total water use and water used by the main life cycle stages.

In addition, internal waste flows have been reported in terms of total solid waste generation and solid waste generation from the main life cycle stages.

Energy consumption of the main life cycle stages has also been reported, in terms of the electricity and fuel consumed in the manufacturing and use of nappies. However, more detailed analysis of energy consumption has not been assessed as energy is generally an intermediate flow, the interaction with the environment is due to resource consumption (e.g. coal use) and combustion products (e.g. CO_2).

3.8 Impact assessment

The impact assessment phase of an LCA assigns the results of the inventory analysis to different impact categories. The following steps are mandatory:

- selection of impact categories and characterisation models;
- classification, the assignment of LCI results; and
- characterisation, the calculation of inventory burdens potential contribution to impacts.

Selection of appropriate impact categories is an important step in an LCA. We assessed the contribution of each system to the following impact indicators, which we believe address the breadth of environmental issues and for which thorough methodologies have been developed. The study employed the problem oriented approach for the impact assessment, which focuses on:

- global warming;
- ozone depletion;
- photo-oxidant formation;
- depletion of abiotic resources;
- eutrophication;
- acidification;
- human toxicity; and
- aquatic and terrestrial toxicity measures (4).

For some impact categories, particularly human toxicity and aquatic and terrestrial eco-toxicity, a number of simplifying assumptions are made in the modelling used to derive characterisation factors. As a result, their adequacy in representing impacts is still the subject of some scientific discussion. However they are still widely used, and we have therefore included them in the assessment as issues of interest, accompanied by caveats describing their deficiencies. The impact assessment reflects potential, not actual, impacts and it takes no account of the local receiving environment.

(4) See Annex B for further description of these impact categories.

The methodology that we used is that developed and advocated by CML (Centre for Environmental Science, Leiden University) and which is incorporated into the SimaPro (5) LCA software tool. The version contained in the software is based on the CML spreadsheet version 2.02 (September 2001) as published on the CML web site and which replaced the preliminary version.

The method used for each impact category for classification and characterisation has been described in *Annex B*.

According to ISO 14042 (ISO, 2000), the following steps may be included but are not mandatory:

- normalisation;
- grouping;
- weighting; and
- data quality analysis.

Whilst some of the category indicator results have been normalised and data quality analysis undertaken, grouping and weighting of indicator results has not be undertaken as part of this study. An important part of the purpose of the study is to indicate the advantages and disadvantages of each system examined in respect of each environmental impact identified, and to highlight hotspots in each system. Neither the Environment Agency, nor the consultants, nor the Advisory Board has any remit to rank the impact categories in order of importance; so weightings have not been applied. Most benefit is obtained by focusing on the quantitative output from LCAs. Therefore, for all three systems, the impacts have been presented separately and an in-depth analysis of each has been made.

3.9 Sensitivity analysis

Key variables and assumptions have been tested to determine their influence on the results of the inventory analysis and impact assessment.

Key areas that have been identified for sensitivity analysis include number of changes and several consumer care characteristics. Due to the permutations associated with reusable nappy systems, sensitivity analysis has formed a significant proportion of the work for this study.

Conclusions made in the study draw on both the primary results for the systems assessed and the variations that result through the sensitivity analysis.

(5) PRé Consultants bv · Plotterweg 12 · 3821 BB Amersfoort · The Netherlands

3.10 Peer review

In accordance with ISO14040, the study has been peer reviewed by an external reviewer. This reviewer's report is included in the final report and details ERM's responses to the review (see *Annex C*)

The reviewer has addressed the issues below:

- *for the goal. and scope*:
  - ensure that the scope of the study is consistent with the goal of the study, and that both are consistent with ISO 14041; and
  - prepare a review statement on the goal and scope.
- *for the inventory*:
  - review the inventory for transparency and consistency with the goal and scope and with ISO14041;
  - check data validation and that the data used are consistent with the system boundaries. It is unreasonable to expect the reviewer to check data and calculations beyond a small sample; and
  - prepare a review statement.
- *for the impact assessment*:
  - review the impact assessment for appropriateness and conformity to ISO14042; and
  - prepare a review statement.
- *for the interpretation*:
  - review the conclusions of the study for appropriateness and conformity with the goal and scope of the study; and
  - prepare a review statement.
- *for the draft final. report*:
  - review the draft final report for consistency with reporting guidelines in ISO 14040 and check that recommendations made in previous review statements have been addressed adequately; and
  - prepare a review statement including consistency of the study and international standards, scientific and technical validity, transparency and relation between interpretation, limitations and goal.

4 Inventory analysis: disposable nappy system modelling

The disposable systems modelled reflect the average child's use of disposable nappies during the first 2.5 years. This child therefore represents children who stop wearing nappies earlier than 2.5 years, see *Section 3.1*.

This chapter describes both the disposable nappy life cycle system assessed, and the process data and the inventories used to generate a complete life cycle inventory for the system assessed, this information is summarised in *Table 4.5*.

The UK sales figure for disposable nappies in 2001-2002 provided an average daily use figure of 4.16 nappies a day, based on a market penetration of 96.4 per cent (Environment Agency, 2004). The Environment Agency surveys (Environment Agency, 2004) suggested a change frequency, for disposable nappy users, between 4.05 and 4.4 per day over 2.5 years. Due to the clarity of the survey questions and responses, the Agency statistician deemed a daily change of 4.16 to be appropriate and one that is supported by the surveys. An average daily change figure of 4.16 has therefore been used in the assessment of the disposable nappy system.

To determine the quantities and type of materials used to manufacture the disposable nappies, the three largest manufacturers of disposable nappies were provided with questionnaires. The questionnaires also addressed all other production process consumption data (energy, water and materials) and emissions data. The results were then weighted by market share (units) to generate a hypothetical 'average' manufacturing plant.

4.1 Disposable nappy manufacturing

Table 4.1 details the inputs and outputs for the average disposable manufacturing plant. *Table 4.2* details how production waste from manufacturing is managed.

A transport distance allocation of 1000 km of transport by sea and 1000 km of road transport has been assumed for all materials. This assumption is based on the fact that materials are sourced predominantly from the UK and Europe. Based on previous studies, ERM believes that transport is likely to make an insignificant contribution to the overall environmental impacts of the systems studied.

Disposable nappies are manufactured using a continuous mechanical process. The process is fully automated, with nappy components fed into the process and finished packaged nappies produced at the end.

Table 4.1 Average manufacturing plant: input/output data per tonne of nappies

INPUTS	Quantity	Unit	OUTPUTS	Quantity	Unit
Materials			**Materials**		
Fluff pulp	425.9	kg	Fluff pulp waste: recycled	18.1	kg
SAP	310.0	kg	SAP waste: recycled	22.3	kg
PP	144.4	kg	PP waste	15.1	kg
PE	116.5	kg	LDPE waste	21.1	kg
Adhesives	31.3	kg	Adhesive waste	4.3	kg
Calcium carbonate	22.1	kg	Calcium carbonate waste	0.4	kg
PDT PET	13.3	kg	PDT PET waste	0.6	kg
Tape	10.5	kg	Tape waste	0.2	kg
Polyester	4.6	kg	Polyester waste	0.9	kg
Elastic	4.1	kg	Elastic waste	0.1	kg
Lotion	0.1	kg	Lotion waste	0.0	kg
Total	1083.0	kg	Total	83.0	kg
Associated packaging			**Associated packaging**		
Stretch wrap	0.64	kg	Stretch wrap waste	0.64	kg
Paper board	9.65	kg	Paper board waste	9.65	kg
Wood (pallets)	5.94	kg	Wood (pallets) waste	5.94	kg
Metal (bale wire)	0.69	kg	Metal (bale wire) waste	0.69	kg
Total	16.92	kg	Total	16.92	kg
Others			**Nappies**	**1000.00**	**kg**
Water (mains supply)	440.3	litres	Transit packaging: Shrinkwrap	30.0	kg
Electricity (National Grid)	674.2	kWh	Polyethylene	16.0	kg
Natural gas	49.7	kWh	Water to sewer	440.26	litres
Product packaging: Primary/secondary			**Product packaging: Primary/secondary**		
HDPE	5.82	kg	HDPE	5.82	kg
Cardboard	7.31	kg	Cardboard	7.31	kg
PE	4.60	kg	PE	4.60	kg
Total	17.73	kg	Total	17.73	kg
Transit packaging			**Transit packaging**		
Polyethylene	32.76	kg	Polyethylene	32.76	kg
Cardboard	17.41	kg	Cardboard	17.41	kg
Total	50.17	kg	Total	50.17	kg

Source: Manufacturers of Disposable Nappies

Table 4.2 Manufacturing waste management per tonne of nappies produced

Materials	Quantity kg	Landfill kg	Recycling kg
Fluff pulp waste	18.1	13.5	4.5
SAP waste	22.3	16.7	5.6
PP waste	15.1	3.8	11.3
LDPE waste	21.1	5.3	15.8
Adhesive waste	4.3	4.3	0.0
Calcium carbonate waste	0.4	0.4	0.0
PDT PET waste	0.6	0.2	0.5
Tape waste	0.2	0.2	0.0
Polyester waste	0.9	0.2	0.7
Elastic waste	0.1	0.1	0.0
Lotion waste	0.0	0.0	0.0
Associated packaging			
Stretch wrap waste	0.64		0.64
Paper board waste	9.65		9.65
Wood (pallets) waste	5.94		5.94
Metal (bale wire) waste	0.69		0.69

4.1.1 Water inventory

Based on data published by Water UK (Water UK, 2003), we have allocated 0.601 kWh per m^3 of water supplied. We have assumed that the energy used is electricity. For every m^3 of water supplied, 0.12 kg of sludge is generated.

Based on data provided by Water UK (Water UK, 2003), we have allocated 0.598 kWh per m^3 of sewage treated. For every m^3 of sewage treated, 0.5 kg of dry sludge is produced. This equates to 12.3 kg of wet sludge per m^3 of sewage. Based on published research for the UK (Huijbregts *et al.* 2002) we have allocated emissions of 0.0129 kg of methane per m^3 of sewage treated. We have also allocated 0.025 kg BOD and 0.125 kg COD and 0.03 kg suspended solids per m^3 of sewage treated (ERM estimate based on typical industry data).

4.1.2 Electricity generation

For all three nappy systems, electricity supply and generation models have been created using fuel mix and supply efficiency data for the UK in 2001 (DTI, 2003). For industrial facilities, we have assumed medium voltage supply. BUWAL 250 (6) life cycle inventories for energy generation system inventories have been used in the modelling.

(6) Environmental Series No. 250/1, Swiss Agency for the Environment, Forests and Landscape (SAEFL) Berne, 1998

4.2 Transport to retail outlets

In the absence of logistics data, because the effort required to collect this was not justified on the basis of its assumed significance, it has been assumed that nappies are transported 500 km to retail outlets in 40 tonne trucks.

4.3 Retail outlet

No data has been collected regarding the energy consumption associated with stores retailing nappies. However, a figure was estimated on the basis of energy use in supermarket stores. A typical supermarket store consumed 3.2 million kWh of electricity in 1998, of which refrigeration accounted for 48 per cent and the bakery 8 per cent (J Sainsbury, 1988). If we allocate the remaining 44 per cent on a sales basis, using an average of £29 million sales per store, this equates to 0.049 kWh per pound sterling or 138 kWh per tonne of nappies, assuming 12.7 pence (WEN, 2004) per nappy.

There are a number of alternative allocation methods that might be considered appropriate for this life cycle stage, such as shelf space. No one method stands apart as being correct and the method chosen is considered reasonable. Other methods would require significant resources to gather the required data to no real advantage.

4.4 Transport home

76 per cent of supermarket customers drive to the supermarket. The majority of shoppers, 65 per cent, travel up to ten minutes and the average 'shop' costs £44.31 (Competition Commission, 2000). If we assume this journey is travelled at a speed of 30 mph, this equates to a journey of five miles each way. Assuming a use figure of 4.16 nappies per day and 12.7 pence per nappy (WEN, 2004), this would equate to an 8.3 per cent allocation of the calculated road transport distance per 'shop' based on cost. Assuming a once weekly shop, over the 2.5 years the child is in nappies the car travel allocated to the purchasing of nappies equates to 108.5 miles (174.6 km).

4.5 Use

Based on an average use figure of 4.16 nappies per day, 3796 nappies would be consumed in the first 2.5 years of a child's life. This usage rate equates to 169.5 kg of nappies to be purchased.

For the disposal of urine and faeces to landfill and incineration we have assessed two scenarios, using *Geigy* (Lenter, 1981) and *Forfar* (Campbell and McIntosh, 1998) data; see *Section 1.3.1.* As there is no definitive data set Geigy data has been used for faeces release in both scenarios. The scenarios were as follows:

- **Geigy Scenario:** using the *Geigy* (Lenter, 1981) urine and faeces data (for both volume and composition), and assuming all excreta generated over the 2.5 year period is captured in the nappies (i.e. no potty training). The use of 3796 nappies would result in 391.4 kg of nappy waste and 3.0 kg (this is only ‘use’ packaging and does not include retail packaging) of packaging waste.

- **Mixed Scenario:** using the *Forfar* (Campbell and McIntosh, 1998) urine data (for urine volume and composition) and *Geigy* (Lenter, 1981) faeces data (for faeces weight and composition), and assuming all excreta generated over the 2.5 year period is captured in the nappies (i.e. no potty training). The use of 3796 nappies would result in 537.6 kg of nappy waste and 3.0 kg of nappy packaging waste.

4.6 Disposal

In the UK in 2000, approximately 8 per cent of municipal solid waste was incinerated and 80 per cent landfilled. The remainder was recycled or composted, neither of which are currently suitable for managing used disposable nappies in the UK. We have therefore assumed that 9 per cent of the waste generated in the use phase is incinerated and 91 per cent is landfilled. We have used the *WISARD* (7) (Ecobalance, 1999) life cycle assessment software tool to generate inventories for the disposal of nappies.

The *WISARD* software tool requires the specification of waste on the basis of the components of municipal waste (see *Annex D* for details of *WISARD*). We have therefore designated excreta as being putrescible waste, fluff pulp as being paper waste and the remainder as plastic waste. *Table 4.4* shows the waste breakdown. *WISARD* quantifies the environmental flows that arise from waste management processes. These will include, inter alia, methane, leachate and combustion products.

The landfill and incinerator inventories for MSW in *WISARD* recover energy through gas management and energy recovery from combustion products. The landfill model assumes 23 per cent fugitive emission of landfill gas and 77 per cent combustion (41 per cent flare and 36 per cent energy recovery) of landfill gas over its life. The incinerator model in *WISARD* assumes that 450 kWh of electricity are generated per tonne of waste. The allocation of excreta as putrescible waste will overestimate the scale of environmental burden, as excreta is has a water content of 86 per cent and putrescible waste in *WISARD* has a moisture content of 62 per cent.

The data presented in *Table 4.3* represent the proportion of children by age that are wearing nappies, based on the user surveys (Environment Agency, 2004). *Table 4.4* shows the quantity of excreta (designated as putrescible fraction) that is contained within nappies for the average child wearing disposables. Excreta generated by children younger than 2.5 years, but who are out of nappies, has been excluded from the study (this has been assumed for all systems assessed).

(7) Waste: Integrated Systems Assessment for Recovery and Disposal

Table 4.3 Children wearing nappies by child age

Age of child	Children wearing nappies (%)	Children not wearing nappies (%)
up to 6 months	100.0%	0.0%
6 to 12 months	95.7%	4.3%
12 to 18 months	82.8%	17.2%
18 to 24 months	45.6%	54.4%
24 to 30 months	17.6%	82.4%
30 to 36 months	4.8%	95.2%
36 to 42 months	1.8%	98.2%
42 to 48 months	0.4%	99.6%
48 to 54 months	0.1%	99.9%
54 to 60 months	0.1%	99.9%
60 to 66 months	0.1%	99.9%

Source: Environment Agency, 2004
Note: The surveys showed that there is no difference in age out of nappies between children using reusable or disposable nappies. This table is true for all children.

Table 4.4 The composition of disposable nappy waste produced during a child's 2.5 years in nappies

Fraction	Quantity kg	Comments
Plastic	99.2	Packaging and nappy materials
Putrescible	*219.0*	*Geigy scenario*
Putrescible	*365.1*	*Mixed Scenario*
Paper	76.0	Paper

4.7 Life cycle inventories used

Table 4.5 details the life cycle inventories that have been used to describe the input and outputs from the disposable nappy system. These flows are presented graphically in *Figure 4.1*, assuming Geigy excreta scenario, and in *Figure 4.2*, assuming the mixed excreta scenario.

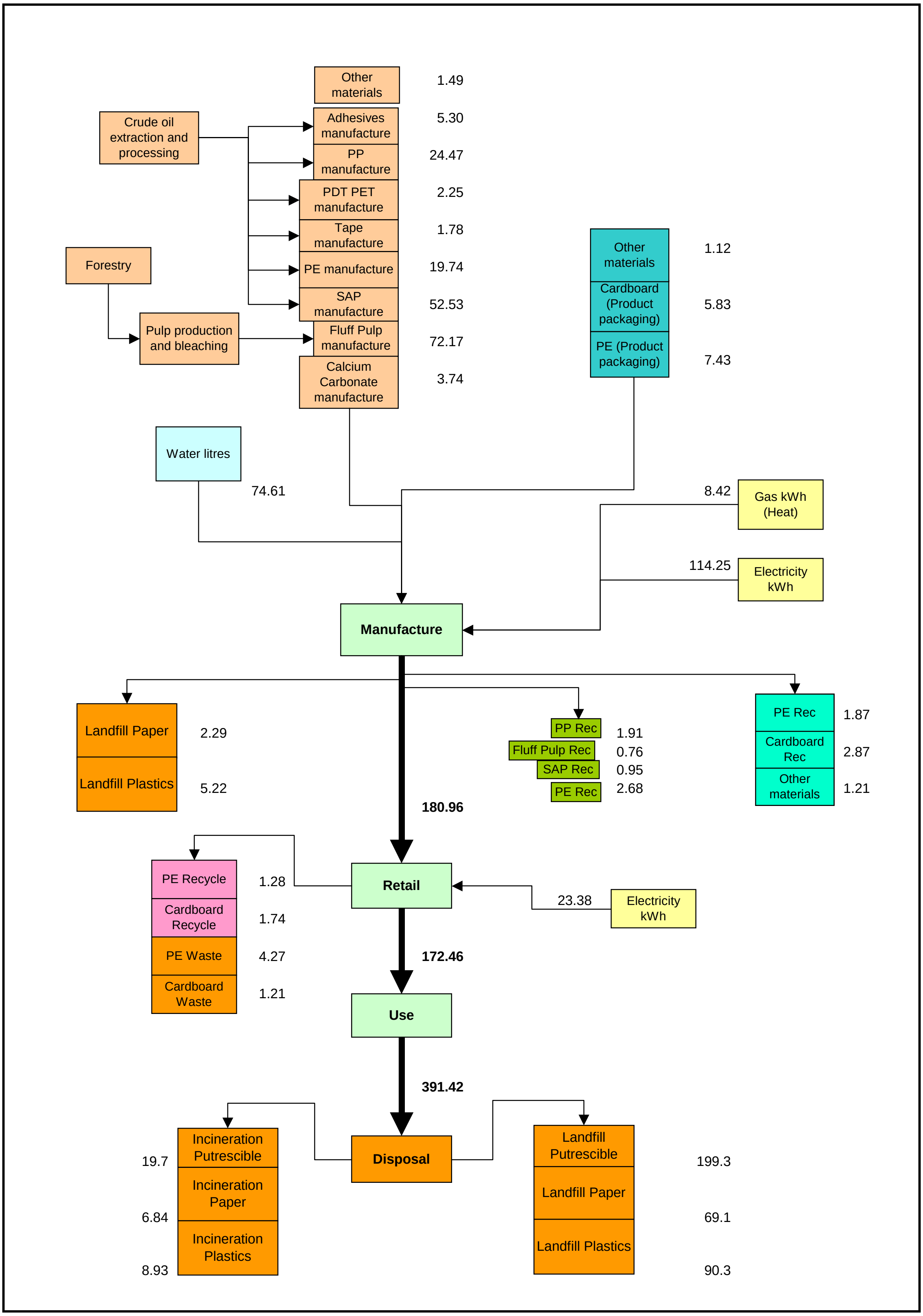


Figure 4.1 System diagram for disposable nappies (Geigy Excreta Scenario)

All units are kilograms unless otherwise stated.

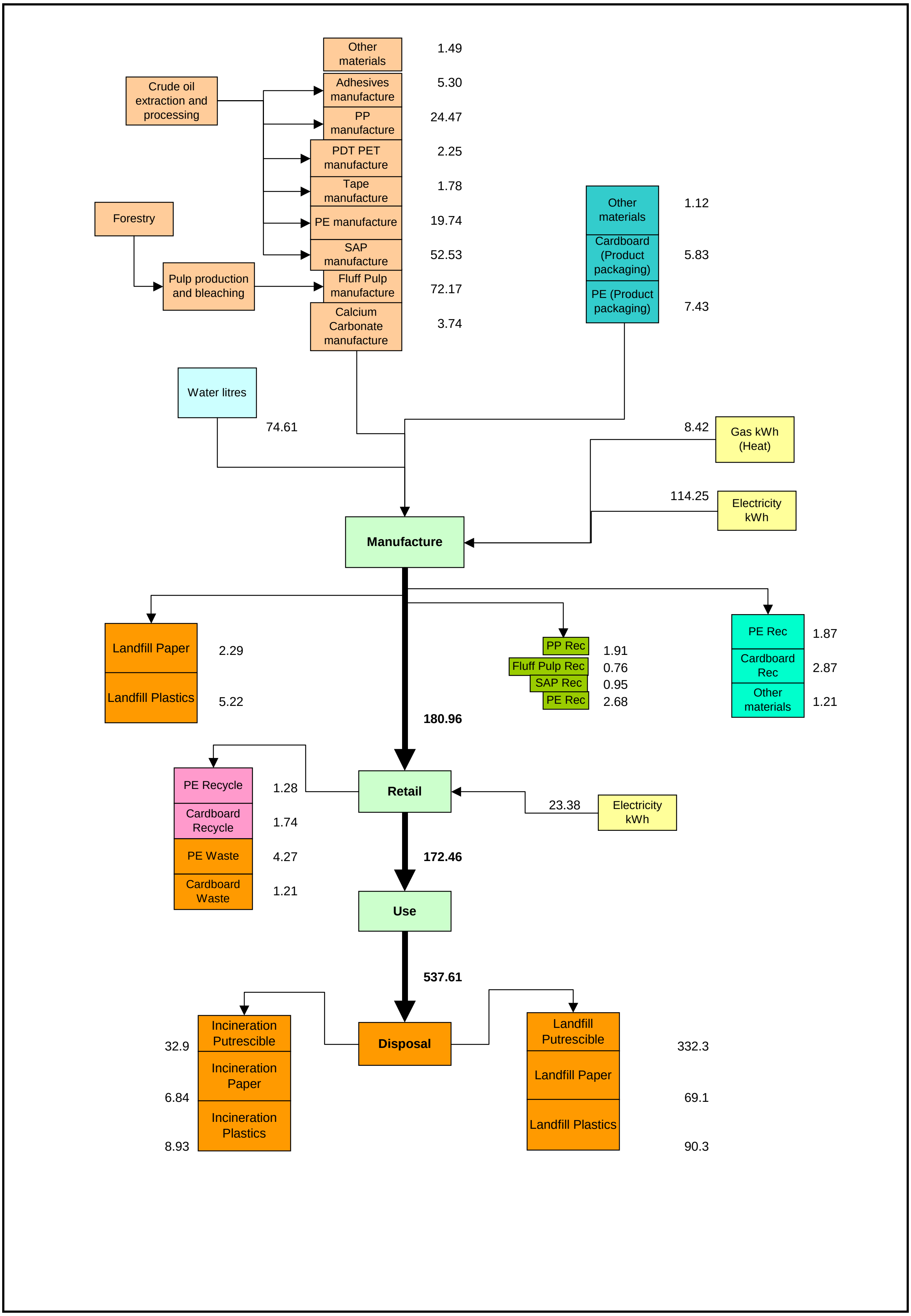


Figure 4.2 System diagram for disposable nappies (Mixed Excreta Scenario)

All units are kilograms unless otherwise stated.

Table 4.5 Life cycle inventory data sources for disposable nappies

Flow	Quantity	Units	Stage	Inventory data	Comment	Age of Data	Geographic Coverage
Fluff pulp	72.17	kg	Input to manufacture	EDANA		2001	Europe
SAP	52.53	kg	Input to manufacture	EDANA		2001	Europe
PP	24.47	kg	Input to manufacture	EDANA		2001	Europe
PE	19.74	kg	Input to manufacture	EDANA		2001	Europe
Adhesives	5.30	kg	Input to manufacture	EDANA		2001	Europe
Calcium carbonate	3.74	kg	Input to manufacture	BUWAL 250	For ground limestone	1993	Germany
PET	2.25	kg	Input to manufacture	APME		1990	Europe
Tape	1.78	kg	Input to manufacture	EDANA		2001	Europe
Other materials	1.49	kg	Input to manufacture	Ignored	Below 1%		
Cardboard packaging	5.83	kg	Input to manufacture	BUWAL		1993	Europe
PE packaging	7.43	kg	Input to manufacture	IDEMAT (APME)		2000	Europe
Other materials	1.12	kg	Input to manufacture	Ignored	Below 1%		
Electricity	114.25	kWh	Input to manufacture	Adjusted BUWAL 250	Adjusted to reflect 2001	Original 1994	UK 2001
Gas	8.42	kWh	Input to manufacture	BUWAL 250	Natural gas heat	1994	Europe
Water	74.61	litres	Input to manufacture	ERM Inventory		2001	UK
Paper landfill	2.29	kg	Output from manufacture	*WISARD*		1997	UK
Plastic landfill	5.22	kg	Output from manufacture	*WISARD*		1997	UK
Fluff pulp recycled	0.76	kg	Output from manufacture	ERM/EDANA	Assumed 80% offset of virgin.	2001	
SAP recycled	0.95	kg	Output from manufacture	ERM/EDANA	Assumed 80% offset of virgin.	2001	
PP recycled	1.91	kg	Output from manufacture	ERM/EDANA	Assumed 80% offset of virgin.	2001	
PE recycled	2.68	kg	Output from manufacture	BUWAL 250 Adjusted	PE Recy.	1994	Europe

Flow	Quantity	Units	Stage	Inventory data	Comment	Age of Data	Geographic Coverage
Other materials	1.21	kg	Output from manufacture	Ignored	Below 1%		
Cardboard recycled	2.87	kg	Output from manufacture	BUWAL		1993	Europe
Electricity	23.38	kWh	Input to retail	Adjusted BUWAL 250	Adjusted to reflect 2001	Original 1994	UK 2001
PE recycled	1.28	kg	Output from retail	BUWAL 250	PE recycling	1994	Europe
Cardboard recycled	1.74	kg	Output from retail	BUWAL 250	Cardboard recycling	1990	Europe
PE waste	4.27	kg	Output from retail	*WISARD*		1997	UK
Cardboard waste	1.21	kg	Output from retail	*WISARD*		1997	UK
Incineration putrescible	19.7	kg	Output from disposal	*WISARD*	Geigy Scenario	1997	UK
Incineration putrescible	32.9	kg	Output from disposal	*WISARD*	Mixed Scenario	1997	UK
Incineration paper	6.84	kg	Output from disposal	*WISARD*		1997	UK
Incineration plastics	8.93	kg	Output from disposal	*WISARD*		1997	UK
Landfill putrescible	199.3	kg	Output from disposal	*WISARD*	Geigy Scenario	1997	UK
Landfill putrescible	332.3	kg	Output from disposal	*WISARD*	Mixed Scenario	1997	UK
Landfill paper	69.1	kg	Output from disposal	*WISARD*			UK
Landfill plastics	90.3	kg	Output from disposal	*WISARD*			UK
Transport of raw materials to Manufacturing	1000	km	Transport	BUWAL 250	40 te truck	1994	Europe
Transport of raw materials to manufacturing	1000	km	Transport	BUWAL	Sea freighter	1994	Europe
Transport of nappy to retail outlet	500	km	Transport	BUWAL 250	40 te truck	1994	Europe
Transport of customer to home	174.6	km	Transport	IDEMAT 2001	Passenger car	1995-99	Europe

Note: see *Section 11.2* for a glossary of life cycle inventory sources.

5 Inventory analysis: home laundered reusable nappy system modelling

This section describes the home laundered reusable nappy life cycle system assessed, together with the process data and the inventories used to generate a complete life cycle inventory for the system assessed. This information is summarised in *Table 5.9*.

Due to the diverse nature of reusable nappies and their use, it was necessary to conduct a number of surveys. The surveys were conducted to determine the types of nappies that are being used as well as how they are being used. The surveys were a sales survey conducted by ERM and user surveys commissioned by the Environment Agency (Environment Agency, 2004). The surveys have been used by ERM to define an average reusable nappy scenario. This scenario is tested in the sensitivity analysis based on the variation found in the surveys. This approach has been decided on due to the diverse nature of nappy use and the differences in the surveys.

5.1 ERM sales survey

ERM conducted a survey of nappy retailers and manufactures that determine the sales of the different nappy types in 2000-2001. The survey was not a complete picture of UK sales as not all companies responded. Terry nappies were most popular and accounted for approximately 37 per cent of (direct to user) nappy sales, with prefold nappies at 25 per cent of sales. Direct to user sales totalled 750,000 nappies. Wrap/pant sales to users amounted to 200,000 wraps/pants, over 60 per cent of which were plastic waterproof pants, which are either manufactured from PVC (polyvinyl chloride) or EVA (ethylene vinyl acetate). This survey suggested that for every 10 nappies purchased, 4.0 wraps/pants are purchased.

5.2 Environment Agency's user surveys

TEST Research (part of the MORI Group of research companies) was commissioned by the Environment Agency to undertake a survey of reusable nappy users.

This survey was conducted amongst parents or guardians of children under the age of 36 months who currently use or have used washable cloth nappies. The purpose of this study was to contribute to the Environment Agency's ability to establish the usage of washable cloth nappies and other related nappy products.

- In total, 183 parents/guardians were interviewed face to face in locations within randomly selected constituencies across Britain. Of the 183 respondents, 135 had a child under the age of 36 months and were using washable cloth nappies, eight of which were using a laundry service. The remaining 48 had used cloth nappies on their child in the recent past. The fieldwork was conducted between 10 March 2003 and 4 April 2003.

A summary of the findings of this and other surveys conducted on behalf of the Environment Agency have been published as a separate report (Environment Agency, 2004).

5.3 Baseline system

Based on the research from the sales survey and the Environment Agency surveys, the following assumptions have been established for the average terry system, shown in *Table 5.1*.

The data presented in *Table 5.1* reflect how consumers use reusable nappies. The systems modelled reflect a decreasing nappy wearing population with time, as with disposable nappies. The data presented in *Table* 4.3 show the proportion of children by age that are wearing nappies, based on the Environment Agency surveys (Environment Agency, 2004).

Table 5.2 details the nappy washing assumptions. The data were taken directly from the Environment Agency surveys (Environment Agency, 2004). We have assumed that nappies are washed every two days. This assumption is based on the survey results for the number of people who soak nappies, the number of nappies owned, daily number of changes and that, on average, the survey found that 12 cloth nappies make up a load.

Table 5.1 Reusable terry nappy system assumptions

Description	Quantity	Unit	Comment	Source/basis
Nappy type	Terry nappy	-	Assumed 100% terry usage.	Sales survey and EA, 2004
Number of nappies purchased	47.5	Assumed number purchased over 2.5 years. Based on the maximum that were owned at any one time.	47.5 relates to terry nappy type.	ERM assumptions based on the survey data (EA, 2004)
Number of changes	6.1	Average daily number for children still in reusable nappies.	Relates to all reusable nappy types.	EA, 2004
Number of changes	4.4 – 4.7	Average daily number for all children who have used reusable nappies. The range relates to uncertainties regarding night time use.	Relates to all reusable nappy types.	EA, 2004

Description	Quantity	Unit	Comment	Source/basis
Liner type	Disposable liners		86% of users consume one per nappy change. Of users, 50% flushed and 50% disposed to household bin.	ERM assumptions based on the survey data (EA, 2004)
Flushing	2.94	Average daily number.	Corresponds to 86% liner use and a 50:50 split between flushable and non flushable liner use	ERM assumption
Number of bowel movements	2.3	Per day.	57% of faeces flushed to sewer and 43% disposed to household bin.	ERM assumption based on non-flushable liner use amongst Terry users
Soaking	80.0%	Of all users in nappies soak.	Sanitiser used for all soaking and occurs every two days.	EA, 2004
Nappy washing	100%	Of all users machine wash.	Washing occurs every two days.	EA, 2004
Softener	49%	Of users in nappies use softener.	Dosage based on product packaging recommendation.	EA, 2004 and ERM estimate.
Wrap/pant type	18.1	Number used over 2.5 years.	Calculated assuming 15 month life. Plastic waterproof wraps/pants	EA, 2004 and ERM estimate based on longevity question.
Booster pads	4.7	Boosters owned over 2.5 years.	Boosters used 26% of the time.	EA, 2004
Purchasing	0.049	kWh of retail electricity consumed per £ spent.	Assumed that nappies and other nappy materials (liner, detergents, wraps/pants, etc) are purchased in a supermarket.	ERM assumption, sales survey and J Sainsbury, 1988
Nappy washing behaviour	See *Table 5.2* detail of washing behaviour.	-	-	EA, 2004
Wrap/pant washing behaviour	6.1	Wraps washed every 2nd use for children still in nappies.	Assumed wraps are machine washed (mixed load) at 40° C and air dried.	EA, 2004

Description	Quantity	Unit	Comment	Source/basis
Drying behaviour	19%	% of nappy washes tumble dried. Remainder are air dried.	Due to lack of clarity in the data, we have assumed this figure.	EA, 2004
Ironing	9.5%	% of all users in nappies that iron.	Assumed 12 nappies take 5 minutes to iron.	EA, 2004
End of life	Nappies are kept for reuse & wraps are disposed as MSW.	-	Assumed nappies are kept for reuse and wraps/pants are disposed of in domestic waste	ERM assumption, sales survey and J Sainsbury, 1988

* Plastic wraps assumed as it is these that would be worn with a terry nappy.

Table 5.2 Nappy washing

Description	Quantity	Unit
Percentage of nappies machine washed	100	%
Percentage of nappies hand washed	0.0	%
Percentage of mixed machine loads	21.0	%
Percentage of separate machine loads	79.0	%
Percentage wash 90° C – nappy	32.1	%
Percentage wash 80° C – nappy	0.0	%
Percentage wash 70° C – nappy	7.1	%
Percentage wash 60° C – nappy	35.7	%
Percentage wash 50° C – nappy	7.1	%
Percentage wash 40° C – nappy	17.9	%

We have assumed that the plastic wraps/pants are machine washed at 40° C and air dried. The survey results related to all types of wraps, some of which are suitable to machine washing. However, we have assumed that all plastic wraps/pants are machine washed and changed every other nappy change.

5.4 Electricity generation

For all three nappy systems, electricity supply and generation models have been created using fuel mix and supply efficiency data for the UK in 2001 (DTI, 2003). For industrial facilities, we have assumed medium voltage supply, for domestic use we have assumed low voltage supply. BUWAL 250 energy generation system inventories have been used in the modelling.

For US electricity input to cotton processing, we have used US specific inventory data published by Franklin Associates, and contained in the SimaPro LCA software.

5.5 Cotton production

Data describing the inputs and outputs associated with the growing and ginning of cotton in the United States has been sourced to enable a life cycle inventory for the production of nappies to be developed. Data specific to the United States has been used due to their availability, quality and the percentage of the world market share that it describes (22 per cent in 2001). Cotton growing regimes are likely to be different in other areas of the world. However, no account of world wide variability has been taken due to the availability of data. The data are shown in *Table 5.3*. No solid waste production has been accounted for as it is considered insignificant.

The following are the main documents from which data was extracted.

- Characteristics and Production Costs of US Cotton Farms, Nora L. Brooks, 2001. USDA.

- USDA Agricultural Chemical Usage 1996 Field Crops Summary.

- 1997 Census of Agriculture; AC97-SP-1USDA. Farm and Ranch Irrigation Survey (1998), Volume 3, Special Studies Part 1.

- Cost of Ginning Cotton. Proceedings of the Beltwide Cotton Conference Volume 1:419-429 (1999).

- National Agricultural Statistics Service, Agricultural Statistics Board, USDA. Crop Production - Annual Summary (Released January 9, 1998).

Table 5.3 Cotton production inputs/outputs per kg of ginned cotton lint produced

Input	Quantity	Unit
Insecticides[1]	0.001801	kg
Herbicides[1]	0.002667	kg
Fungicides[1]	0.000047	kg
Defoliants[1]	0.001017	kg
Fertiliser – nitrogen[1]	0.108	kg
Fertilizer – phosphate[1]	0.0373	kg
Fertilizer – potash[1]	0.0441	kg
Diesel (farm)[2]	0.234747	litre
Electric (farm)[2]	0.210846	kWh
Gas (farm)[2]	0.058687	litre
LPG (farm)[2]	0.023475	litre
Ginning electricity[3]	0.200580	kWh
Seed[2]	0.019241	kg
Water[4]	7103	litres
Output	**Quantity**	**Unit**
Lint	1	kg
Pesticide[5]	0.000225	kg
N[6]	0.00342	kg
P[6]	0.00118	kg
K[6]	0.00139	kg
Defoliant[7]	0.0000509	kg

(1) USDA; Agricultural Chemical Usage 1996 Field crops summary.
(2) Nora L. Brooks, 2001; Characteristics and Production costs of US cotton farms.
(3) US National Cotton Council, for 1997 crop.
(4) USDA, 1998; Farm and Ranch Irrigation Survey 1998.
(5) Robert L. Kellogg, 1999; Trends in the Potential for Environmental Risk from Pesticide Loss from Farm Fields.
(6) First Biennium Report, 1998 – 1999; Precision Agriculture Initiative for Texas High Plains.
(7) Potter Thomas L, Truman Clinton C Bosch David D, Bednarz Craig; 2001. Cotton defoliant losses in surface runoff as a function of active ingredient and tillage practice.

5.6 Cotton yarn production

For yarn spinning, we have allocated material loss and electricity consumption to this stage in the life cycle. Based on work by BTTG (BTTG, 1999) and Rudramoothy *et al.,* (2000), we have allocated 10 kWh per kg of yarn produced and 10 per cent material loss. We have assumed that spinning occurs in the United States. The management of wasted material has been excluded, as it is normal to send this material for recovery/recycling (trash, short fibres and scrap yarn).

5.7 Transport of yarn to the UK

We have allocated 6500 km of sea transport (New York to UK) and 1000 km of road transport (transport in UK and US).

5.8 Nappy and booster manufacture

Manufacturers of terry nappies were contacted and requested to fill in a questionnaire describing the production process. Disappointingly, only one company completed the questionnaire, despite numerous requests by ERM. Therefore, the data described in *Table 5.4* cannot be considered representative of all terry nappies. However, the data set is considered to be of good quality. Furthermore nappy manufacture and cotton production are not the most significant elements of the life cycle (considering the consumption of energy in the use phase and that 47.5 terry nappies would weigh approximately 5.46 kg).

Some terry nappies are produced in the UK, but the majority are believed to be produced in the Far East, India and Pakistan.

The Environment Agency surveys showed an average ownership of 4.7 boosters per child, weighing approximately 0.21 kg, and that boosters are used 26% of the time. Due to the low mass of boosters relative to nappies their manufacture has been excluded.

Table 5.4 Terry nappy manufacturing inputs per tonne of nappies produced

Input	Quantity	kg
Hydrogen peroxide (35%)	71	kg
Formic acid	5	kg
Caustic soda (50%)	18	litres
Optical whitener	18	litres
Softener	30	litres
Water	18,000	litres
Grid electricity	1792	kWh
Natural gas	11,246	kWh

Source: UK terry nappy manufacturer

A survey of terry nappies by ERM found that for every 1 kg of nappies there is an associated 12 g of PE packaging. Terry nappies were found to weigh between 100 g and 130 g. We have used 115 g as an average.

5.9 Wrap/pant manufacture

No specific data were collected regarding wrap/pant production, due to the small quantity of material involved. Plastic wraps/pants were found to range between 14 g and 20 g in weight. We have used 17 g per wrap/pant.

A survey of plastic waterproof wraps/pants by ERM identified two main construction materials. These are EVA (ethylene vinyl acetate) and PVC (polyvinyl chloride).

The average child uses 18.1 wraps/pants. This equates to 0.308 kg of wraps/pants. This is a small quantity of material and has therefore been excluded from the analysis.

5.10 Liner manufacture

No specific data were collected regarding disposable liner production. Based on the Environment Agency survey ERM have assumed 100 per cent disposable liners, 50 per cent flushable and 50 per cent non flushable. Of the terry users who use liners, 94 per cent use disposable liners and of these 53 per cent use flushable and 47 per cent use non-flushable. ERM research identified two main types of liner, non woven polypropylene based and cellulose based liners. We have used generic life cycle data for the production of polypropylene and paper to represent liner manufacture. The average weight of a liner was found to be 1.4 g. Polyethylene packaging associated with the liners amounts to
5.4 g per 100 liners.

5.11 Detergent manufacture

Based on the breakdown of detergent usage in the Environment Agency surveys, ERM has been provided with a weighted average (weighted by type of detergent (Environment Agency, 2004) and recommended dosage) life cycle inventory for detergent use per wash. The inventory includes manufacture of detergent and packaging, transport and post treatment of washing machine effluent. Treatment of effluent from washing machines has therefore been excluded from the inventories generated by ERM. The average dose that this corresponds to is 108 g. This data has been published and peer reviewed (Van Hoof *et al.* 2001, 2003a,b). The average dose that this corresponds to is 108 g. This is consistent with data presented by GEA (GEA, 1995). Their report addressed average consumer behaviour (1994), reporting an average load of 3 kg per wash and an average detergent use of 135 g per wash. The reduction from 135 g to 108 g is consistent with the rise in concentrated detergents. Detergent packaging per wash has been calculated to be 6.6 g. We have assumed that this is cardboard.

5.11.1 Transport to retail outlet

In the absence of logistics data, it has been assumed that nappies and other materials are transported 500 km to retail outlets in 40 tonne trucks, with a utilisation of 75 per cent.

5.12 Retail outlet (detergent, sanitiser, liners, softener)

For the purposes of this study, we have assumed the same electricity consumption per £ of sales as used for retail premises in the disposable system, 0.049 kWh/£.

The unit prices we have used are detailed in *Table 5.5*. These prices are based on an internet search supermarket prices.

There are several allocation methods that are considered appropriate for this life cycle stage, such as shelf space. No one method stands apart as being correct and the method chosen is considered reasonable. The other methods would require significant resources to gather the required data to no real advantage.

Table 5.5 Purchase price of reusable nappy materials

Description	Unit	Price per unit, £	No of units	Cost over 2.5 years
Terry nappy*	1 nappy	1.90	47.5	£90.25
Detergent	1 kg	1.30	30.8	£40.03
Sanitiser	1 kg	6.00	10.2	£61.32
Liners	100	2.70	32.7	£88.31
Softener	1 kg	0.89	15.3	£13.59
Wrap/pant*	1 wrap/pant	0.40	19.2	£7.68
Total				**£301.18**

* Wraps/pants and nappies are a relatively insignificant cost. Therefore we have assumed that they are purchased in a supermarket. In reality, they would be purchased on the high street, via mail order or through the Internet.

5.13 Transport of nappy materials home

As for disposables, 76 per cent of supermarket customers drive to the supermarket. The majority of shoppers, 65 per cent, travel up to ten minutes and the average 'shop' costs £44.31 (Competition Commission, 2000). If we assume this journey is travelled at a speed of 30 mph, this equates to a journey distance of five miles each way. Assuming a shopping value of £301.18, this would equate to a 5.2 per cent allocation of the calculated road transport distance per 'shop' based on cost. Assuming a once weekly shop, over the 2.5 years the child is in nappies this car travel associated with the purchasing of nappies equates to 67.9 miles (109.4 km).

5.14 Nappy use

Children up to 2.5 yrs, who are in nappies, use an average of 6.1 nappies per day, of which 2.3 will contain bowel movements (Environment Agency, 2004). We have assumed that, for every change, 50 per cent of the liners are flushed down the toilet and 50 per cent are disposed of in the household bin (there was an equal split between flushable and non flushable liner use). The Environment Agency surveys showed that 86 per cent of parents use liners in tandem with nappies. Used nappies are soaked in a sanitising solution. Based on the percentage of people soaking, the number of nappies owned and the change frequency we have assumed that nappy washing takes place every two days.

5.14.1 Flushing

According to the National Home Improvement Council, pre 1995 WCs typically consume nine litres per flush. New WCs use a maximum of seven litres per flush.

We have assumed seven litres, this allows for the low flush developments and pre 1995 WCs.

5.14.2 Soaking

We have assumed that 80 per cent of nappies are soaked in a bin and that an average water volume of ten litres is used. For the sanitizer we have assumed that nappy soak is used. The composition of nappy soak is detailed in *Table 5.6*.

Table 5.6 Nappy soak composition

Component	% (Recorded on product packaging)	Assumed
Sodium carbonate	15-30	30
Sodium percarbonate	15-30	30
Organic sequestering agent	5-15	15
Anionic surfactant	<5	5
Cellulose colloids	<5	5
Tetraacetylethylenediamine activator	<5	5

5.14.3 Washing

Using data from Defra's Market Transformation Programme (Defra data), we have calculated that each year 8.5 per cent of washing machines are replaced, this suggest a life span of 11.7 years for a washing machine. To reflect actual energy consumption by washing machines in the UK in 2001-2002, it is appropriate to model machine performance of machines sold in 1995-1996. However, due to data limitations, we have used sales data for 1997 to calculate energy consumption, see *Table 5.7*. This is likely to underestimate energy consumption. AISE in their submission to the European Commission (AISE, 2002) quote average electricity consumption figures, for the UK, per wash, of 1.61 kWh at 60°C, and 2.5 kWh at 90°C. The Group for Efficient Appliances in 1995 report, for Europe, 2.06 kWh for 90°C and 1.19 kWh at 60°C.

According to the Environment Agency [8] washing machines use between 50 and 100 litres per wash. We have assumed 75 litres per wash.

For mixed load washing, we have assumed full loads and allocated consumption data on a mass basis. We have assumed a 3.00 kg average load for mixed loads (GEA, 1995).

(8) Conserving Water in Buildings: Domestic Appliances Leaflet

Table 5.7 Washing machine performance

Parameter	Quantity	Unit	Comment
Average washing machine water use per load	75.0	litres	ERM estimate: average of EA figures
Average electricity use per wash 90° C	1.77	kWh	Based on sales by efficiency class in 1997
Average electricity use per wash 80° C	1.63	kWh	ERM estimate
Average electricity use per wash 70° C	1.50	kWh	ERM estimate
Average electricity use per wash 60° C	1.36	kWh	Based on sales by efficiency class in 1997
Average electricity use per wash 50° C	1.09	kWh	ERM estimate
Average electricity use per wash 40° C	0.82	kWh	Based on sales by efficiency class in 1997
% wash 90° C – nappy	32.1	%	EA survey
% wash 80° C – nappy	0.0	%	EA survey
% wash 70° C – nappy	7.1	%	EA survey
% wash 60° C – nappy	35.7	%	EA survey
% wash 50° C – nappy	7.1	%	EA survey
% wash 40° C – nappy	17.9	%	EA survey
Average electricity use per load	1.38	kWh	Calculated

5.14.4 Detergent use

See *Section 5.11.*

5.14.5 Softener use

Although reusable nappy promoters recommend not to use fabric softener when washing nappies, the Environment Agency's surveys (Environment Agency, 2004) showed that an average of 49% of users in nappies use softener. ERM has determined an average softener dose of 0.1kg per wash, based on product packaging recommendations. The composition of the softener is shown in *Table 5.8*.

Table 5.8 Fabric softener composition

Component	% (Recorded on product Material Safety Data Sheets)	Assumed
Cationic surfactants	5-10%	10%
Water	-	90%

5.14.6 Tumble drier

Due to limitations of the survey, no precise data were gained regarding percentage of washes that are tumble dried. Survey respondents made multiple choices regarding drying. 50 per cent of terry users in the Environment Agency surveys selected the tumble drying option. However, tumble drying selection totalled 19 per cent of all the selections made. We have assumed that tumble driers are used to dry 19 per cent of nappy wash loads. This is considered a weak assumption, and expected to be a minimum. Energy use for tumble driers has been estimated to be 0.75 kWh per kg of cotton. This estimate is based on LCA work undertaken by ERM for Marks and Spencer Plc in 2001-2002 (ERM, 2002).

The Office of National Statistics (ONS) found that depending on socio economic classification that ownership of tumble driers in 2002 ranged from 45 to 71 percent of households, ownership of tumble driers in the UK was 54.5 per cent and is increasing with time (ONS, 2002). 58 per cent of lone parent families own tumble driers and 72 per cent of other families own tumble driers. 65 per cent of small families and 74 per cent of large families own tumble driers (ONS, 2002). The ONS survey does not provide data according to age of children.

The group for efficient appliance suggest an average tumble drier activity of 60 per cent compared with washing (GEA, 1995). This a Europe-wide report and does not reflect families alone.

Different levels of tumble drying has been tested in the sensitivity.

5.14.7 Ironing

We have assumed that 9.5 per cent of all users iron their nappies, based on the Environment Agency's surveys (Environment Agency, 2004). Energy consumption from nappy ironing was based on an iron rated at 1.9 kW and an average ironing time of 5 minutes per 12 nappies. This equates to 0.015 kWh of electricity consumption per 12 nappies.

5.14.8 Wrap/pant washing

Based on the Environment Agency's surveys (Environment Agency, 2004) we have assumed that the plastic wraps/pants are washed in a mixed load at 40°C and air dried. Consumption of water, electricity and detergent associated with mixed load wrap/pant washing has been allocated on a mass basis. We have assumed full loads and allocated consumption data on a 3.00 kg average load (GEA, 1995).

5.14.9 Water supply and disposal

For data used to describe water supply and treatment see *Section 4.1.1*

We have assessed flush and soaking water using the sewage treatment data. Washing machine water consumption and effluent treatment is included in the detergent inventory.

5.15 End of life

We have assumed that nappies are kept for reuse and that wraps/pants are disposed of with domestic waste.

5.16 Life cycle inventories used

Table 5.9 details the life cycle inventories that have been used to describe the input and outputs from the reusable nappy system. These flows are described in *Figure 5.1*, assuming Geigy excreta scenario, and in *Figure 5.2*, assuming the Forfar excreta scenario.

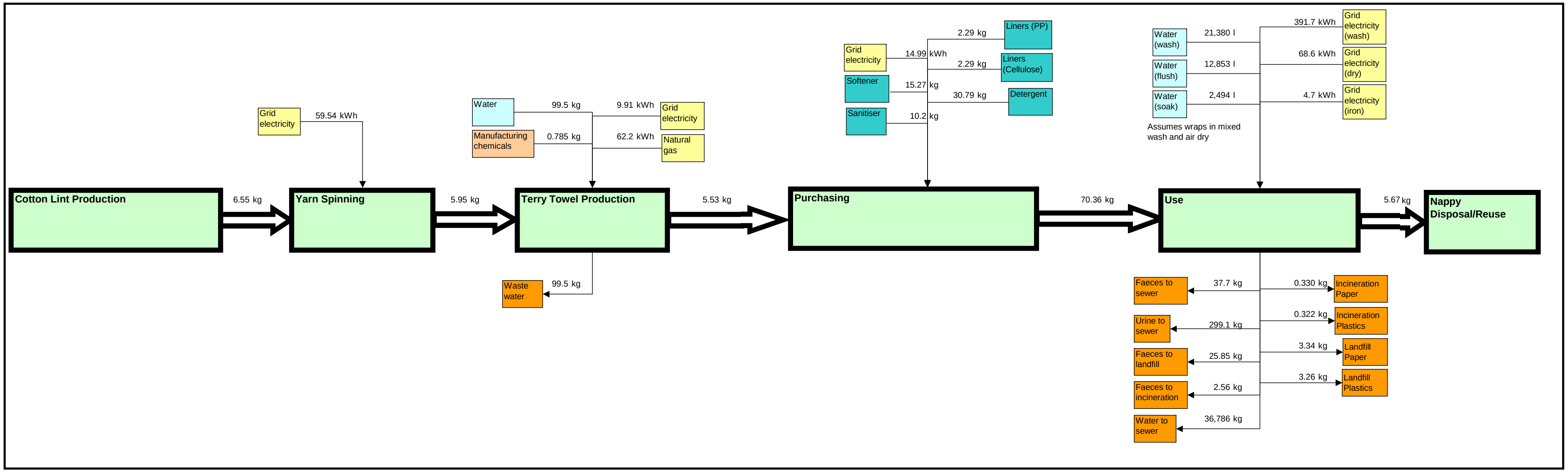


Figure 5.1 System diagram for home use reusable nappies (Geigy Excreta Scenario

All units are kilograms unless otherwise stated

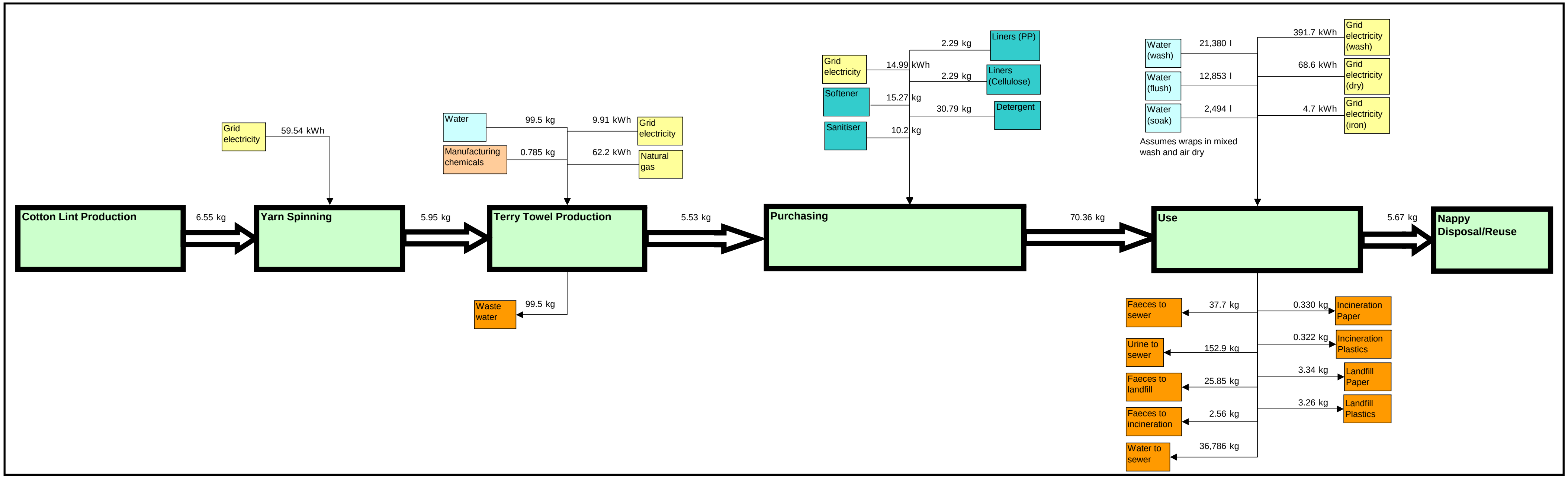


Figure 5.2 System diagram for home use reusable nappies (Forfar Excreta Scenario)

All units are kilograms unless otherwise stated

Table 5.9 Life cycle inventory data sources home use nappies

Flow	Quantity	Units	Stage	Inventory data	Comment	Age of data	Geographic coverage
Grid electricity	59.54	kWh	Input to yarn spinning	Franklin		1995-99	USA
Cotton lint	6.55	kg	Input to yarn spinning	ERM	From US data	1996-2001	USA
Cotton yarn	5.95	kg	Input to terry towel production	ERM	From published material	1990-2000	
Manufacturing chemicals	0.785	kg	Input to terry towel production	ERM/ other sources	Estimates/ generic LCI	1990-2000	Europe
Water	99.5	kg	Input to terry towel production	ERM inventory		2001	UK
Grid electricity	9.91	kWh	Input to terry towel production	Adjusted BUWAL 250	Adjusted to reflect 2001	Original 1994	UK 2001
Natural gas	62.2	kWh	Input to terry towel production	BUWAL 250	Natural gas heat	1994	Europe
Waste water	99.5	kg	Output from terry towel production	Emission			
Terry towel	5.53	kg	Input to purchasing				
Grid electricity	14.99	kWh	Input to purchasing	Adjusted BUWAL 250	Adjusted to reflect 2001	Original 1994	UK 2001
Liners (disposable, PP)	2.29	kg	Input to purchasing	Used EDANA PP data		2001	2001
Liners (disposable, cellulose)	2.29	kg	Input to purchasing	FAL paper towels		1995-99	US
Detergent	30.79	Kg	Input to purchasing	Industry data		2001	UK
Softener	15.27	kg	Input to purchasing	ERM inventory	Based on composition and using TENSIDE inventory data	1994	Europe

Flow	Quantity	Units	Stage	Inventory data	Comment	Age of data	Geographic coverage
Sanitiser	10.2	kg	Input to purchasing	ERM inventory	Based on composition and using TENSIDE data	1994	Europe
Grid electricity (wash)	391.7	kWh	Input to use phase	Adjusted BUWAL 250	Adjusted to reflect 2001	Original 1994	UK 2001
Grid electricity (dry)	68.6	kWh	Input to use phase	Adjusted BUWAL 250	Adjusted to reflect 2001	Original 1994	UK 2001
Grid electricity (iron)	4.7	kWh	Input to use phase	Adjusted BUWAL 250	Adjusted to reflect 2001	Original 1994	UK 2001
Water (washing)	21,380	litres	Input to use phase	ERM inventory		2001	UK
Water (flushing)	12,853	litres	Input to use phase	ERM inventory		2001	UK
Water (soaking)	2494	litres	Input to use phase	ERM inventory		2001	UK
Faeces to sewer (Geigy)	37.7	kg	Output from use phase	ERM Inventory	Geigy scenario	2001	UK
Urine to sewer (Geigy)	152.9	kg	Output from use phase	ERM inventory	Geigy scenario	1001	UK
Faeces to landfill (Geigy)	25.85	kg	Output from use phase	*WISARD*	Geigy scenario	1997	UK
Faeces to incineration (Geigy)	2.56	kg	Output from use phase	*WISARD*	Geigy scenario	1997	UK
Faeces to sewer (Forfar)	37.7	kg	Output from use phase	ERM inventory	Mixed scenario	2001	UK
Urine to sewer (Forfar)	299.1	kg	Output from use phase	ERM inventory	Mixed scenario	2001	UK
Faeces to landfill (Forfar)	25.85	kg	Output from use phase	*WISARD*	Mixed scenario	1997	UK
Faeces to incineration (Forfar)	2.56	kg	Output from use phase	*WISARD*	Mixed scenario	1997	UK

Flow	**Quantity**	**Units**	**Stage**	**Inventory data**	**Comment**	**Age of data**	**Geographic coverage**
Water to sewer	36,785	kg	Output from use phase	ERM sewage treatment inventory	used for flush and soaking water 44279 litres	2001	UK
Incineration paper	0.330	kg	Output from use phase	*WISARD*		1997	UK
Incineration plastics	0.322	kg	Output from use phase	*WISARD*		1997	UK
Landfill paper	3.34	kg	Output from use phase	*WISARD*		1997	UK
Landfill plastics	3.26	kg	Output from use phase	*WISARD*		1997	UK
Transport of yarn	1000	km	Transport	BUWAL 250	40 te truck	1994	Europe
Transport of yarn	6500	km	Transport	BUWAL	Sea freighter	1994	Europe
Transport of nappy material to retail outlet	500	km	Transport	BUWAL 250	40 te truck	1994	Europe
Transport of customer home	123	km	Transport	IDEMAT 20001	Passenger car	1995-99	Europe

Note: see *Section 11.2* for a glossary of life cycle inventory sources.

6 Inventory analysis: reusable commercially laundered nappy system modelling

This section describes the commercially laundered reusable nappy life cycle system that has been assessed, together with the process data and the inventories used to generate a complete life cycle inventory for the system assessed, this information is summarised in *Table 6.8*.

ERM provided UK reusable nappy service providers and nappy manufacturers with questionnaires. The questionnaires were used to determine the quantities and type of materials used in the manufacture and delivery of commercially laundered nappies, also addressed was the process consumption (energy, water and materials) and emissions data. Three laundry service questionnaires were fully completed and one was partially completed. All the data reviewed were used to generate a hypothetical ‘average’ service provider, weighted by market share (units). The four service providers represented an annual service provision of nearly 1.8 million nappies. One nappy manufacturer completed the manufacturing questionnaire.

A nappy laundry service delivers to the user’s home on a weekly basis, the necessary supply of cotton reusable nappies, disposable liners and deodoriser discs. Polyester wraps/pants are supplied on a one-off basis. Soiled nappies, which are stored in a dry deodorised bin in the home, are collected at the same time as the delivery of clean nappies. The laundry service will rinse, wash, and tumble dry soiled nappies before delivery by van to the customer. Users of this service do not need to purchase any further supplies of nappies.

Based on responses from nappy laundries, it has been calculated that the average service provider delivers approximately 37.7 prefold nappies (or 2.85 kg) per child per week for the 2.5 years that the child is in nappies. Based on communication with commercial laundries, we have assumed that the average service provider will stock 52.5 prefold nappies (or 3.96 kg) per child over the 2.5 year period.

As detailed earlier, a number of surveys (Environment Agency, 2004) were commissioned relating to the use of reusable nappies. These surveys have been used by ERM to define some of user activities in the home (wrap washing, flushing etc.).

Table 6.1 Commercially laundered reusable nappy assumptions

Description	Quantity	Unit	Comment	Source
Nappy type	Prefold	52.5	Assumed 100% prefold usage.	EA, 2004 and ERM research
Number of changes	6.1	Average daily number	6.1 relates to all reusable nappy types	EA, 2004
Number of changes	4.4 – 4.7	Average daily number for all children	Relates to all reusable nappy types	EA, 2004
Liner type	Disposable liners		86% of users consume one per nappy change. Of users, 50% flushed and 50% disposed to household bin	EA, 2004
Flushing	2.94	Average daily number	Corresponds to liner flushing and number of bowel movements	EA, 2004
Number of bowel movements	2.3	Per day	Excreta is disposed with liners, and for those not using liners it is flushed	ERM calculation
Wrap/pant type	6.6	Number used over 1 year	Polyester wraps/pants	ERM survey of laundry service providers
Wrap/pant washing behaviour	100%	Percentage assumed to machine wash wraps/pants	Assumed mixed load of 3 kg total weight at 40° C and air dried	ERM survey
Booster pads	-	-	Assumed that booster pads are not used	
Purchasing	0.049	kWh of retail electricity consumed per £ spent	Assumed that only detergent for wrap washing is purchased	ERM research
End of life	Assumed nappies are sold for reuse and wraps/pants are disposed of in domestic waste. No burden has been allocated for final disposal of nappies	-	-	

The commercially laundered inventory analysis reflects the average UK child using a commercial laundry. It therefore takes account of the decreasing nappy wearing population, as with the disposable and reusable systems. The data presented in *Table 4.3* show the proportion of children by age that are wearing nappies, based on consumer surveys (Environment Agency, 2004).

6.1 Electricity generation

For all three nappy systems, electricity supply and generation models have been created using fuel mix and supply efficiency data for the UK in 2001 (DTI, 2003). For industrial facilities, we have assumed medium voltage supply, and for domestic use, we have assumed low voltage supply. BUWAL 250 energy generation system inventories have been used in the modelling.

For the electricity input into prefold manufacture we have used Pakistan energy data for 2001, sourced from the International Energy Agency. We have used BUWAL 250 energy generation system inventories to generate a Pakistan specific inventory in the modelling

6.2 Cotton production

See *Section 5.5* for data describing the inputs and outputs associated with cotton growing and ginning.

6.3 Nappy manufacture

Manufacturers of prefold nappies were contacted and requested to fill in a questionnaire describing the production process. There was a disappointing response to the questionnaires, not all companies responded, and only one fully completed questionnaire was received, despite repeated reminders by ERM. As such, the data described in *Table 6.2* that represents cotton spinning, weaving, bleaching and stitching processes, is not considered representative of all prefold nappies. However, the data set is considered to be of good quality and nappy manufacture and cotton production are not the most significant elements of the life cycle (considering the consumption of energy in the use phase and that 52.5 terry nappies would weigh approximately 3.96 kg). The data shown in *Table* 6.2 represent spinning, weaving and stitching to produce one tonne of prefold nappies. The overall production loss for these processes is 12 per cent by weight.

The majority of prefold nappies are thought to be produced in the Far East, India and Pakistan. For the basis of this study, we have assumed Pakistan.

Table 6.2 Prefold nappy manufacturing inputs per tonne of prefold nappies produced

Prefold production	Quantity	Unit
Cotton lint	1120	kg
Ground water	42000	kg
Electricity	51100.0	kWh
Gas	10553.2	kWh
Hydrogen peroxide	292	kg

Source: Prefold nappy manufacturer in Pakistan

No data were collected for emissions to air. However, generic life cycle data for the combustion of fuels has been used. Primary data was available for the emissions to water, which is shown in *Table 6.3* and *Table 6.4*. For the emissions to surface water, we have accounted for these as environmental burdens and for emissions to sewer, we have used the inventory for sewage treatment (See *Section 4.1.1*) amended for electricity generation in Pakistan.

Table 6.3 Emissions to surface water

Description	Quantity	Unit
BOD	80 to 100	mg/l
COD	500	mg/l
Suspended solids	200 to 250	mg/l
Aluminium	0	mg/l
Ammonia	2	mg/l
Chloride	1000	mg/l
Chromium	1	mg/l
Cyanide	1	mg/l
Fluorides	15	mg/l
HCl	15	mg/l
Iron	2.5	mg/l
Lead	0.1	mg/l
Mercury	18	mg/l
Nickel	0.08	mg/l
Nitrates	20	mg/l
Nitrogen	0	mg/l
Oil & grease	1 to 5	%
Other acid	0	mg/l
Pesticides	0	mg/l
Phosphates	18	mg/l
Phosphorus	0	mg/l
Sulphates	350	mg/l
Sulphuric acid	20	mg/l
Tin	1	mg/l
Zinc	0.7	mg/l

Table 6.4 Effluent emissions to sewer

Description	Quantity	Unit
BOD	150	mg/l
COD	500	mg/l
Suspended solids	190	mg/l
Aluminium	0	mg/l
Ammonia	5	mg/l
Chloride	400	mg/l
Chromium	2	mg/l
Cyanide	1	mg/l
Fluorides	15	mg/l
HCl	10	mg/l
Iron	2.5	mg/l
Lead	0.5	mg/l
Mercury	10	mg/l
Nickel	1	mg/l
Nitrates	12	mg/l
Nitrogen	0	mg/l
Oil & grease	0.05	%
Other acid	0	mg/l
Pesticides	0	mg/l
Phosphates	10	mg/l
Phosphorus	0	mg/l
Sulphates	120	mg/l
Sulphuric acid	15	mg/l
Tin	0.8	mg/l
Zinc	0.1	mg/l

For sewage treatment, equivalent performance to UK sewage treatment has been assumed.

It has been assumed that there is no significant packaging associated with the manufacture of prefold nappies. On analysis of prefold nappies provided to ERM it was found that the average weight of a prefold nappy is 75.5 g.

6.4 Transport of prefold nappies to the UK

We have allocated 11,000 km of sea transport (Pakistan to Southampton via the Suez canal) and 1000 km of road transport.

6.5 Wrap/pant manufacture

No specific data were collected regarding wrap production, due to the small quantity of material involved. It is common to use polyester wraps in combination with prefold nappies. Commercial laundries do not launder wraps but sell wraps to their customers.

A survey of polyester wraps by ERM generated an average weight of 43 g. The average user consumes 6.6 wraps per year that a child is in nappies. This equates to 0.485 kg of wraps. We have used generic life cycle inventory data for the production of polyester fabric.

6.6 Liner manufacture

See *section 5.10*.

6.7 Commercial detergent use by laundries

Detergent composition and consumption for the 2.5 year period was determined based on the breakdown of detergent usage from the ERM questionnaire supplied to commercial laundry service providers, and through contacting the detergent manufacturers. This is shown in *Table 6.5*. ERM conducted a survey that determined the detergent packaging per 1 kg of detergent to be 0.002 kg PP (polypropylene) and 0.0003 kg PE (polyethylene). ERM has generated a life cycle inventory for the production of detergent primarily based on life cycle inventory data from EMPA (EMPA, 2002).

Table 6.5 Detergent compositions

Item	Ingredient	Quantity (%)	Assumed (%)	Active amount (kg) used in 2.5 years	Total amount (kg) used in 2.5 years
Detergent powder	Sodium carbonate	>30%	30%	1.830	6.10
	Disodium metasilicate	15-30%	30%	1.830	
	Sodium hydroxide	5-15%	15%	0.915	
	Alkyl alcohol alkoxylate	<5%	5%	0.305	
Sodium perborate powder	Sodium perborate tetrahydrate	>98%	98%	2.431	2.48
Sodium hypochlorite	Sodium hypochlorite	10-13%	13%	0.368	2.83
Neutraliser	Disodium disulphite	>30%	30%	0.321	1.07

6.7.1 Transport to laundry service provider

In the absence of logistics data, it has been assumed that nappies and other materials are transported 500 km.

It has been assumed that laundry service providers supply nappies, wraps and liners. Wraps are assumed to be washed in the home, and, only, nappies are collected by the nappy laundry service provider for cleaning.

6.8 Laundry service vehicle use

Prefold nappies and other accessories are delivered on a once weekly basis by van. Based on the ERM survey, the average round trip delivery distance is 3.88 miles per child per week, which equates to a distance of 504.7 miles (ie 812 km) over the 2.5 year period. The associated fuel consumption per average child for the first 2.5 years is shown in *Table 6.6*. The service providers contacted use a mixture of vehicles and fuels.

Table 6.6 Nappy laundry service vehicle fuel use per child per 2.5 years

Input	Quantity	Unit
Diesel	21.3	litres
Petrol	0.55	litres
Liquefied propane gas (LPG)	8.0	litres

6.9 Laundry service washing

Based on data from the ERM survey of commercially laundered nappy service providers, the following data were determined (*Table 6.7*) relating to a service provision of 2.5 years period per child. The data presented in *Table* 6.7 represents an average service provider.

Table 6.7 Inputs to prefold nappy laundry service for the first 2.5 years of an average child's life

Input	Quantity	Unit
Grid electricity	331.6	kWh
Natural gas	1093.5	kWh
Water	16,097	kg
Detergent powder	6.10	kg
Sodium perborate powder	2.48	kg
Sodium hypochlorite	2.83	kg
Neutraliser	1.07	kg
Wraps/pants*	0.485	kg
Liners (disposable, PP) *	2.29	kg
Liners (disposable, cellulose)*	2.29	kg
PP packaging	0.036	kg
PE packaging	0.181	kg

* Not all laundry service providers supply all the necessary liners and wraps used during the 2.5 years a child is in nappies. However, in this scenario we have assumed that they do.

No data for laundry effluent quality was collected. We have used the inventory for sewage treatment, see *Section 5.14.9*.

6.10 Retail outlet (nappies)

For the purposes of this study, it has been assumed that all nappy materials, except for detergent used for wrap/pant washing, are supplied by the service provider. See *Section 6.11.3* for details of wrap/pant washing.

6.11 Nappy use

For children in nappies, 6.1 nappies on average are used per day, of which 2.3 will contain bowel movements. We have assumed that, for every change, 50% of the liners are flushed down the toilet and 50% are disposed of in the household bin. The consumer surveys (Environment Agency, 2004) showed that liners are used 86% of the time. Used nappies are stored in a dry bin until collection.

6.11.1 Flushing

According to the National Home Improvement Council, pre 1995 WCs typically consume nine litres per flush. New WCs use a maximum of seven litres per flush. We have assumed seven litres per flush. Excreta and liner disposal have been modelled in the same way as for the reusable home use system.

6.11.2 Nappy storage

We have assumed that all used nappies are stored in a dry bin and that deodoriser tablets are not used.

6.11.3 Wrap washing

We have assumed that wraps are washed in a mixed load (ie with other washing) at 40°C.

Using data from Defra's Market Transformation Program (Defra data), we have calculated electricity use per wash by wash temperature for an average washing machine, based on the market penetration of different energy grade washing machines, see *Section 5.14.3.*

According to the Environment Agency washing machines use between 50 and 100 litres per wash. We have assumed 75 litres per wash.

For consumption of water, electricity and detergent associated with mixed load wrap washing, we have assumed full loads and allocated consumption data on a mass basis. We have assumed a 3.00 kg total average load for mixed loads (GEA, 1995).

6.11.4 Home detergent use

See *Section 5.11* for details regarding detergent use.

6.11.5 Water supply and disposal

See *Section 5.14.9* for details relating to water supply and disposal.

6.12 End of life

We have assumed that nappies are sold by service providers for reuse and that wraps are disposed of with household waste.

6.13 Life cycle inventories used

Table 6.8 details the life cycle inventories that have been used to describe the input and outputs from the commercially laundered nappy system. These flows are presented graphically in *Figure 6.1*, assuming Geigy excreta scenario, and in *Figure 6.2* assuming the Forfar excreta scenario.

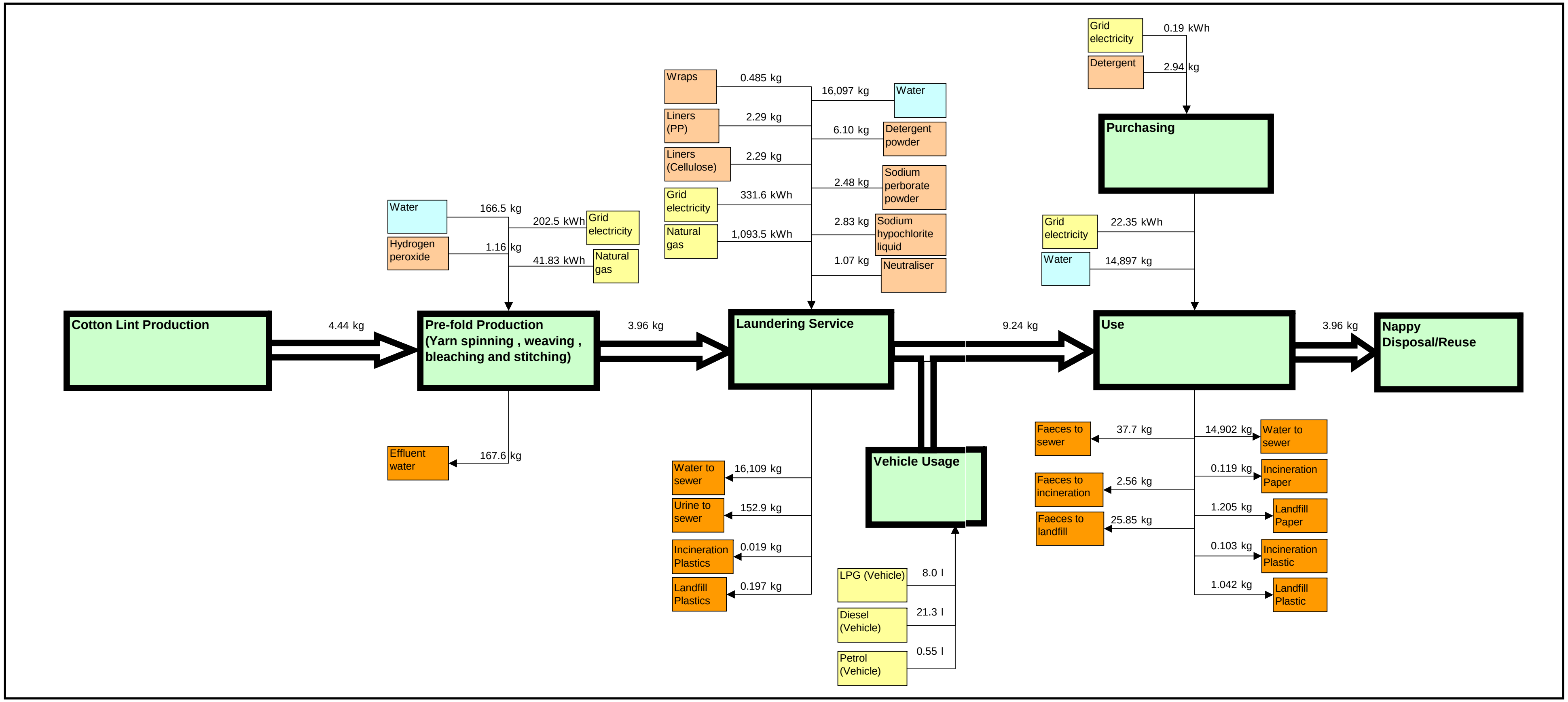


Figure 6.1 System diagram for commercially laundered reusable nappies (Geigy Excreta Scenario)

All units are kilograms unless otherwise stated.

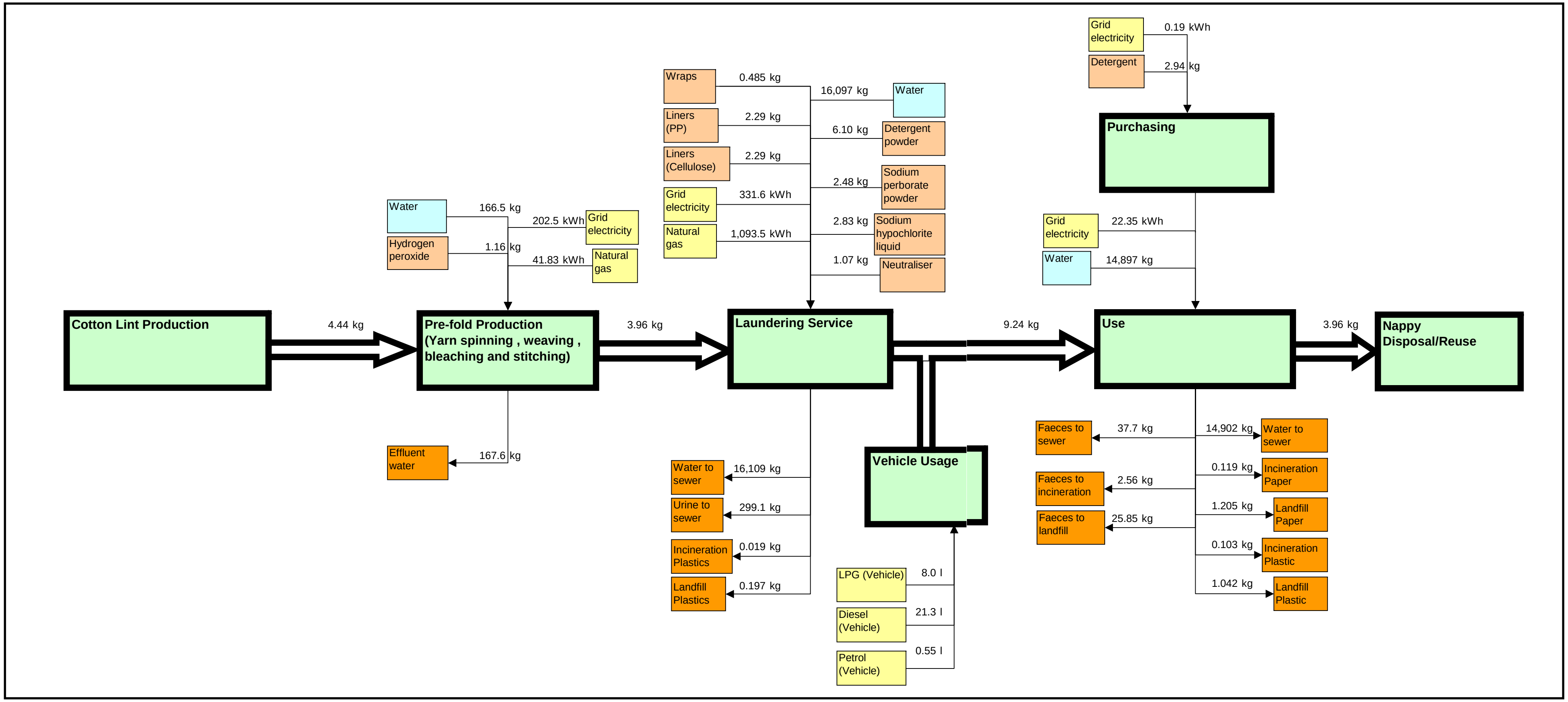


Figure 6.2 System diagram for commercially laundered reusable nappies (Forfar Excreta Scenario)

All units are kilograms unless otherwise stated.

Table 6.8 Life cycle inventory data sources of commercially laundered nappies

Flow	Quantity	Units	Stage	Inventory data	Comment	Age of data	Geographic coverage
Cotton lint	4.44	kg	Input to prefold production	ERM	From US Data amended for Pakistan	1996-2001	Pakistan
Hydrogen peroxide	1.16	kg	Input to prefold production	Hydrogen peroxide EMPA			
Water	166.5	kg	Input to prefold production	ERM inventory		2001	UK
Grid electricity	202.5	kWh	Input to prefold production	Adjusted BUWAL 250	ERM adjusted to reflect 2001	Original 1994	Pakistan
Natural gas	41.83	kWh	Input to prefold production	BUWAL 250	Natural gas heat	1994	Europe
Waste water	167.6	kg	Output from prefold production	ERM Inventory		2001	UK
LPG	8.0	litres	Input to vehicle usage	IDEMAT 2001		1995-99	Europe
Diesel	21.3	litres	Input to vehicle usage	IDEMAT 2001		1995-99	Europe
Petrol	0.55	litres	Input to vehicle usage	IDEMAT 2001		1995-99	Europe
Grid electricity	331.6	kWh	Input to laundering service	Adjusted BUWAL 250	ERM adjusted to reflect 2001	Original 1994	UK
Natural gas	1093.5	kWh	Input to laundering service	BUWAL 250	Natural gas heat	1994	Europe
Prefold nappies	3.96	kg					
Water	16097	kg	Input to laundering service	ERM inventory		2001	UK

Flow	Quantity	Units	Stage	Inventory data	Comment	Age of data	Geographic coverage
Wraps/pants	0.485	kg	Input to laundering service	IDEMAT	Polyester fabric	1994	Europe
Liners (disposable, PP)	2.29	kg	Input to laundering service	Used EDANA PP data		2001	2001
Liners (disposable, cellulose)	2.29	kg	Input to laundering service	FAL paper towels		1995-99	US
Detergent powder	6.10	kg	Input to laundering service	ERM inventory	Estimate using EMPA data	1990-2001	UK
Sodium perborate powder	2.48	kg	Input to laundering service	ERM inventory from EMPA Data		1992	UK
Sodium hypochlorite	2.83	kg	Input to laundering service	ERM inventory	Estimate based	1990-2000	UK
Neutraliser	1.07	kg	Input to laundering service	ERM inventory	Estimate		UK
Water to sewer	16109	kg	Output from laundering service	ERM inventory		2001	UK
Urine to sewer (Geigy)	152.9	kg	Output from laundering service	ERM inventory	Geigy scenario	2001	UK
Urine to sewer (Forfar)	299.1	kg	Output from laundering service	ERM inventory	Mixed Scenario	2001	UK
Incineration plastics	0.0195	kg	Output from laundering service	*WISARD*		1997	UK
Landfill plastics	0.197	kg	Output from laundering service	*WISARD*		1997	UK

Flow	Quantity	Units	Stage	Inventory data	Comment	Age of data	Geographic coverage
Grid electricity	0.19	kWh	Input to purchasing phase	Adjusted BUWAL 250	ERM Adjusted to reflect 2001	Original 1994	UK
Detergent	2.94	Kg	Input to purchasing phase	Industry data		2001	UK
Water	14897	litres	Input to use phase (flushing and wrap/pant washing)	ERM inventory		2001	UK
Grid electricity	22.35	kWh	Input to use phase (flushing and wrap/pant washing)	Adjusted BUWAL 250	ERM Adjusted to reflect 2001	Original 1994	UK
Faeces to sewer	37.7	kg	Output from use phase	ERM inventory	Geigy scenario	2001	UK
Faeces to incineration	2.56	kg	Output from use phase	*WISARD*	Geigy scenario	1997	UK
Faeces to landfill	25.85	kg	Output from use phase	*WISARD*	Geigy scenario	1997	UK
Faeces to sewer	37.7	kg	Output from use phase	ERM inventory	Mixed scenario	2001	UK
Faeces to incineration	2.56	kg	Output from use phase	*WISARD*	Mixed scenario	1997	UK
Faeces to landfill	25.85	kg	Output from use phase	*WISARD*	Mixed scenario	1997	UK
Water to sewer	14902	kg	Output from use phase	ERM inventory		2001	UK
Incineration paper	0.119	kg	Output from use phase	*WISARD*		1997	UK

Flow	Quantity	Units	Stage	Inventory data	Comment	Age of data	Geographic coverage
Landfill paper	1.205	kg	Output from use phase	*WISARD*		1997	UK
Transport of prefold nappy	1000	km	Transport	BUWAL 250	40 te truck	1994	Europe
Transport of prefold nappy to retail outlet	11000	km	Transport	BUWAL	Sea freighter	1994	Europe
Transport of prefold nappy to retail outlet	500	km	Transport	BUWAL 250	40 te truck	1994	Europe

Note: see *Section 11.2* for a glossary of life cycle inventory sources.

7 Inventory analysis: results for disposable and reusable nappy systems

7.1 Disposable nappies

Summary inventory data for the disposable nappy system, assuming 4.16 changes per day, are detailed in *Table 7.1* and *Table 7.2*. Manufacture of disposable nappy materials and production of disposable nappies result in the majority of the inventory burdens assessed. End of life waste management is the most significant source of methane emissions and, as would be expected, dominates solid wastes disposed (this is an internal flow).

Table7.1 Inventory analysis - disposable nappy (Mixed Scenario 1 child, 2.5 years, 4.16 changes)

					Life Cycle Stage		
Substance	**Flow Type**	**Unit**	**Total – all life cycle stages**	**Consumer transport home**	**Raw materials, transport and nappy manufacture**	**Retail and transport to retail**	**End of life waste management**
CO_2 (fossil)	Air	%	100	7.7	89.2	5.1	-2.0
		kg	490	38	437	25	-10
CO_2 (renewable)	Air	%	100	0.0	50.5	0.2	49.3
		kg	260	0	131	1	128
Methane	Air	%	100	0	19.8	1.6	78.5
		kg	6.09	0	1.21	0.10	4.79
N_2O	Air	%	100	35	48	6	11
		kg	0.0201	0.0070	0.0096	0.0012	0.0023
NO_X as NO_2	Air	%	100	9.8	83.3	5.0	1.9
		kg	2.65	0.26	2.20	0.13	0.05
SO_x	Air	%	100	0.8	102.0	3.4	-5.7
		kg	2.04	0.02	2.08	0.07	-0.12
Coal	Resource	%	100	0.0	120.0	14.9	-34.8
		kg	50.8	0.0	60.9	7.6	-17.7
Crude oil	Resource	%	100	9.8	86.2	3.2	0.9
		kg	108	11	93	3	1
Natural gas	Resource	%	100	0.6	98.5	0.6	0.2
		kg	87.9	0.6	86.6	0.5	0.2

Substance	Flow Type	Unit	Total – all life cycle stages	Life Cycle Stage Consumer transport home	Raw materials, transport and nappy manufacture	Retail and transport to retail	End of life waste management
Water	Resource	%	100	0	99.5	0.4	0.1
		kg	34383	1	34200	135	47
Solid waste (9)	Waste	%	100	0	10.6	1.1	88.4
		kg	663	0	70	7	585
BOD	Water	%	100	0	17.4	0.6	82.1
		kg	1.02	0	0.18	0.01	0.84
COD (10)	Water	%	100	0	108.0	-8.1	0.0
		kg	1.40	0	1.51	-0.11	0

Note: Negative values in the table relate to the environmental benefit associated with recycling materials and recovering energy.

Table7.2 Inventory analysis - disposable nappy (Geigy 1 child, 2.5 years, 4.16 changes)

Substance	Flow Type	Unit	Total	Life Cycle Stage Consumer transport home	Retail and transport to retail	Raw materials, transport and nappy manufacture	End of life waste management
CO_2 (fossil)	Air	%	100	7.6	5	88.6	-1.2
		kg	493	38	25	437	-6
CO_2 (renewable)	Air	%	100	0.0	0.2	58.9	40.9
		kg	223	0	1	131	91
Methane	Air	%	100	0.0	2.1	25.3	72.7
		kg	4.78	0	0.1	1.21	3.47
N_2O	Air	%	100	35	6	49	10
		kg	0.0197	0.00698	0.0012	0.0096	0
NO_X as NO_2	Air	%	100	9.8	5.1	83.7	1.4
		kg	2.63	0.26	0.13	2.2	0.04
SO_x	Air	%	100	0.8	3.3	101	-4.9
		kg	2.06	0.02	0.07	2.08	-0.10
Coal	Resource	%	100	0	14.1	113	-27.4

(9) Internal flow that is reported as a point of interest.
(10) The COD emission for end of life is considered too low and is the result of COD being under reported in *WISARD*.

Substance	Flow Type	Unit	Total	Life Cycle Stage			
				Consumer transport home	**Retail and transport to retail**	**Raw materials, transport and nappy manufacture**	**End of life waste management**
		kg	53.7	0	7.6	60.9	-14.7
Crude oil	Resource	%	100	9.8	3.2	86.4	0.6
		kg	107	11	3	93	1
Natural gas	Resource	%	100	0.6	0.6	98.6	0.1
		kg	87.8	0.6	0.5	86.6	0.1
Water	Resource	%	100	0.0	0.4	99.5	0.1
		kg	34362	1	135	34200	27
Solid waste (11)	Waste	%	100	0	1.4	13.5	85.2
		kg	519	0	7	70	442
BOD	Water	%	100	0	0.7	22.3	77.0
		kg	0.797	0	0.006	0.178	0.613
COD (12)	Water	%	100	0	-8	108	0
		kg	1.40	0	-0.11	1.51	0

Note: Negative values in the table relate to the environmental benefit associated with recycling materials and recovering energy.

The differences in the mixed and Geigy scenario inventory tables result from the different quantities of putrescible material sent to landfill and incineration.

Table7.3 is an analysis of the inventory burdens for disposable nappy manufacture. The main sources for the inventory burdens assessed are the production of the main materials of manufacture for disposables and the generation of the electricity used in disposable nappy fabrication.

(11) Internal flow that is reported as a point of interest.
(12) The COD emission for end of life is considered too low and is the result of COD being under reported in *WISARD*.

Table7.3 Inventory analysis - disposable nappy manufacture

Substance	Flow Type	Unit	Total	Fluff pulp	SAP	PE film	Adhesives	Lime stone	Adhesive tape	PET	PP	Cardboard and plastic packaging	Transport	Electricity	Heat gas	Waste recycling	Waste disposal
CO_2 (fossil)	Air	%	100	7.6	36.0	11.0	3.5	0	1.3	2.2	18.1	2.6	4.5	15.4	0.4	-2.9	0.2
		kg	437	33	157	48	16	0	6	10	79	11	20	67	2	-13	1
CO_2 (renewable)	Air	%	100	100.0	0	0	0	0	0	0	0.0	0	0	0.0	0	-0.8	0.7
		kg	131	131	0	0	0	0	0	0	0	0	0	0	0	-1	1
Methane	Air	%	100	4.2	26.0	13.2	3.8	0	1.6	2.1	25.1	0.6	2.0	19.6	0.4	-3.4	4.8
		kg	1.21	0.05	0.31	0.16	0.05	0	0.02	0.02	0.30	0.01	0.02	0.24	0	-0.04	0.06
N_2O	Air	%	100	83.6	3.5	0	0.6	0	0.3	0	0	2.4	4.9	4.8	0.2	-0.8	0.4
		kg	0.0096	0.0080	0.000 3	0	0.0001	0	0	0	0	0.0002	0.0005	0.0005	0	-0.0001	0
NO_X as NO_2	Air	%	100	15.1	25.3	10.7	3.1	0	1.2	1.9	19.5	4.4	15.0	7.1	0.1	-2.9	-0.5
		kg	2.20	0.33	0.56	0.24	0.07	0	0.03	0.04	0.43	0.10	0.33	0.16	0	-0.06	-0.01
SO_x	Air	%	100	8.2	30.8	12.0	3.3	0	1.3	4.8	28.2	3.6	2.4	8.9	0	-3.6	0
		kg	2.08	0.17	0.64	0.25	0.07	0	0.03	0.10	0.59	0.08	0.05	0.19	0	-0.07	0
Coal	Resource	%	100	3.7	26.0	6.5	2.0	0	0.9	1.6	13.1	1.6	0.2	44.9	0	-1.9	1.4
		kg	60.9	2.2	15.8	4.0	1.2	0	0.5	1.0	8.0	1.0	0.1	27.3	0	-1.2	0.8
Crude oil	Resource	%	100	6.8	31.6	15.8	5.4	0	1.9	2.5	26.9	6.9	6.5	0.7	0	-3.9	-1.2
		kg	92.8	6.3	29.3	14.7	5.0	0	1.8	2.3	25.0	6.4	6.0	0.7	0	-3.6	-1.1
Natural gas	Resource	%	100	3.7	38.8	18.7	4.1	0	1.7	0.8	20.0	8.3	0.3	8.2	0.8	-3.9	-1.5
		kg	86.6	3.2	33.6	16.2	3.6	0	1.5	0.7	17.3	7.2	0.3	7.1	0.7	-3.4	-1.3
Water	Resource	%	100	51.9	22.0	3.7	2.2	0	1.4	0	20.6	0.5	0.0	0	0	-2.4	-0.1
		kg	34081	17700	7510	1260	767	0	490	0	7050	178	0	0	0	-834	-40
Solid waste (1)	Waste	%	100	23.0	42.3	3.8	2.6	0.6	5.1	0.4	6.1	1.8	0	0	0	-1.6	14.8
		kg	70.2	16.1	29.7	2.6	1.9	0.4	3.6	0.3	4.3	1.2	0	0	0	-1.1	10.4
BOD	Water	%	100	85.2	2.0	1.8	0.2	0	0.1	1.1	0.9	1.7	0	0	0	-1.0	7.0
		kg	0.178	0.152	0.004	0.003	0.000	0	0.000	0.002	0.002	0.003	0	0	0	-0.002	0.013
COD (2)	Water	%	100	93.6	1.9	1.0	1.0	0	0.5	0.3	0.8	1.3	0.1	0	0	-1.0	-0.2
		kg	1.51	1.41	0.03	0.02	0.01	0	0.01	0.00	0.01	0.02	0	0	0	-0.01	0

(1) Internal flow that is reported as a point of interest.
(2) The COD emission for end of life is considered too low and is the result of COD being under reported in *WISARD*.

7.2 Reusable nappies home use

Table7.4 details the summary inventory for the reusable nappy system. The main sources for the inventory burdens assessed are the production of detergent and the generation of the electricity used in nappy washing. Terry nappy manufacture is a generally small contributor to the life cycle inventory burdens assessed, with the exception of water use; cotton growing being a major user of unprocessed water.

7.3 Commercial laundry

Table details the summary inventory for the commercial laundry nappy system. The main sources for the inventory burdens assessed are the production and use of electricity and gas by laundries, the transport of nappies to and from the home. Prefold nappy manufacture is a surprisingly high contributor to the life cycle inventory burdens assessed. By comparison with home use, more nappies are used over the 2.5 years, which would account for some of the increase in the contribution from nappy manufacture. The data for prefold nappy manufacture suggests it is also more energy intensive than terry nappy manufacture.

Table7.4 Inventory analysis - cloth nappy home use (Mixed Scenario: 1 child, 2.5 years)

				Life Cycle Stage										
Substance	**Flow Type**	**Unit**	**Total – for life cycle**	**Terry towel nappy manufacture**	**Sanitiser**	**Detergent**	**Liners**	**Softener**	**Mains water supply**	**Transport to retail and retail electricity**	**Consumer transport home**	**Home electricity use**	**Sewage treatment**	**Waste management**
CO_2 (fossil)	Air	%	100	13.8	2.9	12.7	3.5	0.6	1.1	2.3	4.7	57.6	1.1	-0.2
		kg	507	70	15	64	18	3	5	12	24	292	5	-1
CO_2 (renewable)	Air	%	100	0.1	0.0	36.0	22.5	2.7	0	0	0	0	0	38.7
		kg	23	0	0	8	5	1	0	0	0	0	0	9
Methane	Air	%	100	7.2	1.9	13.4	2.3	1.0	0.9	1.6	0	46.7	10.1	14.9
		kg	2.2	0.2	0.0	0.3	0.1	0	0	0	0	1.0	0.2	0.3
N_2O	Air	%	100	13.9	1.1	50.5	0.2	0.5	0.2	0.7	22.0	10.0	0.2	0.6
		kg	0.02	0.003	0	0.010	0	0	0	0	0.004	0.002	0	0
NO_X as NO_2	Air	%	100	18.3	2.2	13.4	6.1	1.3	0.8	4.6	10.1	42.3	0.8	0.2
		kg	1.6	0.3	0.0	0.2	0.1	0	0	0.1	0.2	0.7	0	0.0
SO_x	Air	%	100	20.3	3.6	20.5	9.1	1.1	0.8	1.5	0.5	42.1	0.8	-0.3
		kg	1.9	0.4	0.1	0.4	0.2	0	0	0.0	0	0.8	0	0
Coal	Resource	%	100	11.5	3.2	9.0	1.4	0.3	1.3	2.1	0	70.5	1.3	-0.6
		kg	168	19	5	15	2	0	2	4	0	118	2	-1
Crude oil	Resource	%	100	10.3	6.0	29.7	10.6	4.7	0.2	3.6	24.1	10.5	0.2	0.2
		kg	28	3	2	8	3	1	0	1	7	3	0	0
Natural gas	Resource	%	100	16.4	1.5	14.9	7.2	2.2	1.0	1.7	0.6	53.5	1.0	0
		kg	57	9	1	9	4	1	1	1	0	31	1	0
Water	Resource	%	100	54.8	0.9	25.5	0.8	0.2	17.8	0	0	0	0	0
		kg	85964	47200	740	21900	664	156	15300	0	0	0	0	4
Solid waste (1)	Waste	%	100	3.2	0.1	13.7	0.6	0.0	0.6	0	0	0	68.6	13.2
		kg	284	9	0	39	2	0	2	0	0	0	195	38
BOD	Water	%	100	0.1	0	81.0	0.6	0.2	0	0	0	0	15.3	2.7
		kg	2.1	0	0	1.7	0	0	0	0	0	0	0.3	0.1
COD (2)	Water	%	100	0.3	0.2	66.9	0.4	0.1	0	0	0	0	32.2	0
		kg	6.1	0	0	4.1	0	0	0	0	0	0	2.0	0

(1) Internal flow that is reported as a point of interest.
(2) The COD emission for end of life is considered too low and is the result of COD being under reported in *WISARD*.

Table 7.5 Inventory analysis - commercial laundry (Mixed Scenario: 1 child, 2.5 years)

				Life Cycle Stage												
Substance	**Flow Type**	**Unit**	**Total**	**Prefold nappy manufacture**	**Wraps**	**Liners**	**Laundry Detergent**	**Perborate**	**Sodium hypochlorite**	**Neutra-liser**	**Heat gas**	**Electricity**	**Laundry vehicles**	**Home care**	**Mains water**	**Sewage treatment**
CO_2 (fossil)	Air	%	100	19.0	1.4	2.5	1.0	0.6	0.1	0	31.8	27.7	10.2	4.1	0.8	0.8
		kg	705	134	10	18	7	4	1	0	224	196	72	29	6	6
CO_2 (renewable)	Air	%	100	0	0	37.6	0	0	0	0	0	0	0	62.4	0	0
		kg	13.7	0	0	5.2	0	0	0	0	0	0	0	8.6	0	0
Methane	Air	%	100	9.7	0.1	2.1	0.8	0.2	0.1	0	25.9	28.1	0	22.8	0.8	9.5
		kg	2.5	0.2	0	0.1	0	0	0	0	0.6	0.7	0	0.6	0	0.2
N_2O	Air	%	100	21.3	0	0.3	0.3	0.1	0.1	0	15.0	8.3	46.5	7.5	0.2	0.2
		kg	0.02	0.003	0	0	0	0	0	0	0.002	0.001	0.008	0.001	0	0
NO_X as NO_2	Air	%	100	20.4	4.1	6.0	1.3	0.7	0.2	0	14.1	28.0	18.7	4.9	0.8	0.8
		kg	1.6	0.3	0.1	0.1	0	0	0	0	0.2	0.5	0.3	0.1	0	0
SO_x	Air	%	100	39.3	2.8	9.3	1.5	1.1	0.4	0.1	6.8	28.9	2.8	5.2	0.8	0.9
		kg	1.9	0.7	0.1	0.2	0	0	0	0	0.1	0.5	0.1	0.1	0	0
Coal	Resource	%	100	4.3	0.1	2.2	1.9	1.2	0.3	0	3.2	73.2	0.1	9.4	2.1	2.2
		kg	108	5	0	2	2	1	0	0	3	79	0	10	2	2
Crude oil	Resource	%	100	39.7	3.9	5.3	1.1	0.3	0.1	0.1	1.3	3.5	42.3	2.0	0.1	0.1
		kg	55	22	2	3	1	0	0	0	1	2	23	1	0	0
Natural gas	Resource	%	100	13.6	0.4	2.9	0.6	0.3	0	0	64.0	14.4	0.8	2.3	0.4	0.4
		kg	142	19	1	4	1	0	0	0	91	21	1	3	1	1
Water	Resource	%	100	49.8	0.0	1.0	0.5	0.1	0	0	0	0	0	23.4	25.2	0.0
		kg	63900	31800	10	664	290	36	22	2	0	0	4	15000	16100	0
Solid waste (1)	Waste	%	100	0.3	0	0.4	0	0.2	0	0	0	0	0	48.4	0.5	50.1
		kg	406	1	0	2	0	1	0	0	0	0	0	196	2	203
BOD	Water	%	100	1.3	0.3	1.5	0	0	0	0	0	0	0	56.7	0	40.1
		kg	0.8	0	0	0	0	0	0	0	0	0	0	0.5	0	0.3
COD (2)	Water	%	100	1.4	0.1	0.5	0.1	0.1	0	0	0	0	0	48.3	0	49.5
		kg	4.1	0.1	0	0	0	0	0	0	0	0	0	2.0	0	2.1

(1) Internal flow that is reported as a point of interest.
(2) The COD emission for end of life is considered too low and is the result of COD being under reported in *WISARD*.

8 Impact assessment

8.1 Disposable nappies

Table 8.1 details the impact assessment for the disposable nappy scenarios, assuming 4.16 changes per day. The use of different excreta generation has little effect on the impact assessment.

Table 8.1 Impact profile for disposable nappy systems (1 child 2.5 years 4.16 Changes per Day)

Impact category	Unit ($_{eq}$ – equivalents)	Mixed Scenario	Geigy Scenario
Abiotic resource depletion	kg Sb eq	4.82	4.85
Global warming (GWP100)	kg CO2 eq	626.0	602.0
Ozone layer depletion (ODP)	kg CFC-11 eq	0.000261	0.000202
Photochemical oxidation	kg C2H2	0.174	0.163
Acidification	kg SO2 eq	3.78	3.79
Eutrophication	kg PO4 eq	0.338	0.337
Human toxicity	*kg 1,4-DB eq*	*49.4*	*48.9*
Fresh water aquatic ecotox.	*kg 1,4-DB eq*	*7.01*	*5.98*
Terrestrial. ecotoxicity	*kg 1,4-DB eq*	*1.92*	*1.9*

Note: italics indicate less well developed impact methodologies

8.1.1 Analysis of the mixed scenario

Table 8.2 details the contributions to the impact assessment for the mixed disposable nappy scenario, assuming 4.16 changes per day. As can be seen from the most significant elements of the life cycle are upstream of nappy retail (including material production), with the exception of ozone depletion and aquatic toxicity impacts, end of life waste management being a significant contributor. Transport home by consumers contributes a surprising amount of the impact burdens. Disposable nappy manufacture is further analysed in *Table 8.12*.

Table 8.2 Impact profile for disposable nappy system (Mixed Scenario: 1 child, 2.5 years, 4.16 changes)

Impact Category	Unit	Total	Raw materials, nappy manufacture and transport to retail	Retail electricity and packaging	Consumer transport home	End of life waste management
Abiotic resource depletion	%	100	96.0	3.8	4.7	-4.4
	kg Sb eq	4.82	4.63	0.18	0.22	-0.21
Global warming (GWP100)	%	100	74.3	4.4	6.4	15.0
	kg CO_2 eq	626	465	27	40	94
Ozone layer depletion (ODP)	%	100	8.8	7.7	0	83.6
	kg CFC-11 eq	0.00026	0.000023	0.000020	0	0.000219
Photochemical oxidation	%	100	57.4	3.7	16.1	22.9
	kg C_2H_2	0.174	0.100	0.006	0.028	0.040
Acidification	%	100	95.1	3.9	3.9	-3.0
	kg SO_2 eq	3.78	3.60	0.15	0.15	-0.11
Eutrophication	%	100	93.2	4.8	0	2.0
	kg PO_4 eq	0.338	0.315	0.016	0	0.007
Human toxicity	*%*	*100*	*82.1*	*17.8*	*0*	*0.1*
	kg 1,4-DB eq	*49.4*	*40.5*	*8.8*	*0*	*0.1*
Fresh water aquatic ecotoxicity	*%*	*100*	*38.7*	*12.9*	*0*	*48.4*
	kg 1,4-DB eq	*7.01*	*2.72*	*0.91*	*0*	*3.4*
Terrestrial. ecotoxicity	*%*	*100*	*86.2*	*4.8*	*0*	*9.0*
	kg 1,4-DB eq	*1.92*	*1.66*	*0.09*	*0*	*0.17*

Note: ital.ics indicate less well developed impact methodologies

The following nine tables identify which of the individual environmental burdens in the inventory are responsible for the impact values above.

Table 8.3 Global warming

Substance	Flow	Percentage of Total Impact
Methane	Air	20.4
CO_2 (fossil)	Air	78.2
Remaining substances		1.4

Table 8.4 Ozone depletion

Substance	Flow	Percentage of Total Impact
HCFC-22	Air	2.6
1,1,1-trichloroethane	Air	11.1
HALON-1301	Air	15.6
CFC-12	Air	70.6
Remaining substances		0.1

Table 8.5 Acidification

Substance	Flow	Percentage of Total Impact
SO_x	Air	4.8
NO_x	Air	4.9
SO_x (as SO_2)	Air	7.0
NO_x (as NO_2)	Air	30.1
SO_2	Air	53.1
Remaining substances		0.1

Table 8.6 Abiotic resource depletion

Substance	Flow	Percentage of Total Impact
Coal		13.8
Natural gas		40.9
Crude oil		45.0
Remaining substances		0.2

Table 8.7 Eutrophication

Substance	Flow	Percentage of Total Impact
Phosphate	Water	1.9
COD	Water	9.1
NO_x (as NO_2)	Air	87.6
Remaining substances		1.4

Table 8.8 Photochemical oxidation

Substance	Flow	Percentage of Total Impact
Acetaldehyde	Air	1.3
Ethene	Air	6.7
Methane	Air	21.0
CO	Air	23.5
SO_2	Air	46.1
Remaining substances		1.5

Table 8.9 Human toxicity

Substance	Flow	Percentage of Total Impact
Se	Water	1.1
Cd	Air	3.5
Dioxins (TEQ)	Water	3.7
PAHs	Water	4.9
NOx (as NO_2)	Air	5.5
Benzene	Air	6.7
Ni	Air	7.6
Ba	water	7.7
HF	Air	14.8
Metals	Air	18.3
PAHs	Air	24.6
As	Air	-1.9
Remaining substances		3.4

Table 8.10 Fresh water aquatic ecotoxicity

Substance	Flow	Percentage of Total Impact
Metallic ions	Water	1.0
V	Water	1.5
Metals	Air	1.7
PAHs	Water	3.4
Cd	Water	4.4
Dioxins (TEQ)	Water	5.2
Zn	Water	17.1
Ba	Water	19.8
Ni	Water	20.0
Cu	Water	20.7
Remaining substances		5.3

Table 8.11 Terrestrial ecotoxicity

Substance	Flow	Percentage of Total Impact
V	Air	1.1
Metals	Air	14.1
Hg	Air	83.3
Remaining substances		1.5

8.1.2 Disposable nappy manufacturing

Table 8.12 shows the contribution from each element of the life cycle upstream of retail to the impacts associated with their total contribution. The production of super absorbent polymer is the largest source of environmental impact burdens for these stages of the life cycle. Fluff pulp is not as significant as would be expected considering the quantity of material. To check that the data provided was reasonable, we have conducted a comparison of the fluff pulp inventory from EDANA with the BUWAL inventory for bleached sulphate pulp. This comparison showed the fluff pulp inventory to be have higher impact values for the main environmental impact categories. This is presented in *Figure 8.1*. As the fluff pulp inventory is more up to date and specific to disposable nappies it is considered reasonable.

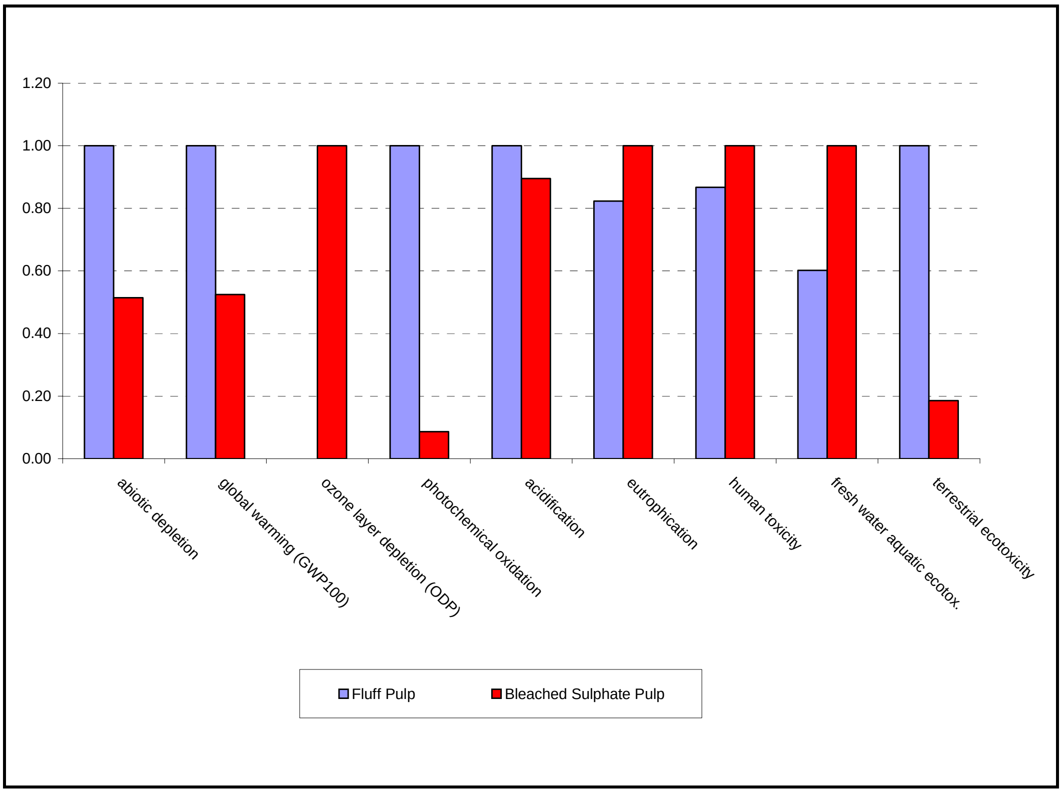


Figure 8.1 Pulp comparison

8.2 Reusable nappies home laundering

Table 8.13 details the impact assessment for the reusable home laundering nappy systems, for 1 child and 2.5 years. Electricity use for nappy care is the most significant single contributor to the impacts assessed.

Table 8.12 Impact profile - disposable nappy manufacture (1 child, 2.5 years, 4.16 changes)

Impact Category	Unit	Total	Fluff pulp	SAP	PE film	Adhesives	Limestone	Adhesive tape	PET	PP	Cardboard and plastic packaging	Transport	Electricity	Heat gas	Waste recycling	Waste disposal
Abiotic resource depletion	%	100	4.9	33.6	15.4	4.3	0	1.7	1.6	21.6	6.6	2.8	11.6	0.4	-3.5	-0.9
	kg Sb eq	4.63	0.23	1.56	0.71	0.20	0	0.08	0.07	1.00	0.30	0.13	0.54	0.02	-0.16	-0.04
Global warming (GWP100)	%	100	7.9	35.2	11.1	3.5	0	1.3	2.2	18.4	2.5	4.4	15.6	0.4	-2.9	0.5
	kg CO_2 eq	465	37	164	52	17	0	6	10	86	12	20	73	2	-14	2
Ozone layer depletion (ODP)	%	100	0	0	0	0	0.1	0	0	0	2.9	75.3	8.3	0.1	0.0	13.1
	kg CFC-11 eq	0.000023	0	0	0	0	0	0	0	0	0.000001	0.000017	0.000002	0	0	0.000003
Photochemical oxidation	%	100	11.4	35.2	13.7	4.0	0	1.5	1.6	30.9	0.3	3.0	1.9	0.1	-4.0	0.5
	kg C_2H_2	0.100	0.011	0.035	0.014	0.004	0	0.002	0.002	0.031	0	0.003	0.002	0	-0.004	0
Acidification	%	100	10.3	29.1	11.6	3.3	0	1.3	3.9	25.5	3.9	6.3	8.4	0.1	-3.4	-0.2
	kg SO_2 eq	3.60	0.37	1.05	0.42	0.12	0	0.05	0.14	0.92	0.14	0.23	0.30	0	-0.12	-0.01
Eutrophication	%	100	24.6	23.3	9.9	3.2	0	1.1	0	17.9	1.1	13.7	7.4	0.1	-2.7	0.4
	kg PO_4 eq	0.315	0.078	0.073	0.031	0.010	0	0.004	0	0.057	0.003	0.043	0.023	0	-0.009	0.001
Human toxicity	*%*	*100*	*6.2*	*25.7*	*2.0*	*5.5*	*0*	*0.8*	*2.1*	*4.3*	*1.8*	*10.9*	*39.6*	*0.5*	*-0.9*	*1.6*
	kg 1,4-DB eq	*40.5*	*2.5*	*10.4*	*0.8*	*2.2*	*0*	*0.3*	*0.9*	*1.7*	*0.7*	*4.4*	*16.0*	*0.2*	*-0.4*	*0.7*
Fresh water aquatic ecotox.	*%*	*100*	*6.5*	*4.2*	*0.7*	*0.5*	*0*	*0.1*	*0.6*	*1.1*	*1.1*	*11.6*	*71.1*	*0.1*	*-0.3*	*2.6*
	kg 1,4-DB eq	*2.72*	*0.18*	*0.12*	*0.02*	*0.01*	*0*	*0*	*0.02*	*0.03*	*0.03*	*0.31*	*1.93*	*0*	*-0.01*	*0.07*
Terrestrial. ecotoxicity	*%*	*100*	*5.7*	*47.9*	*11.6*	*2.4*	*0*	*1.4*	*1.4*	*17.4*	*0.4*	*0.6*	*13.7*	*0.1*	*-3.1*	*0.5*
	kg 1,4-DB eq	*1.66*	*0.09*	*0.79*	*0.19*	*0.04*	*0*	*0.02*	*0.02*	*0.29*	*0.01*	*0.01*	*0.23*	*0*	*-0.05*	*0.01*

Note: italics indicate less well developed impact methodologies

Table 8.13 Impact profile - cloth nappy home laundering (Mixed Scenario: 1 child, 2.5 years)

Impact Category	Unit	Total	Terry towel nappy manufacture	Sanitiser	Detergent	Liners	Softener	Mains water supply	Transport to retail and retail electricity	Consumer transport home	Home electricity use	Sewage treatment	Waste management
Abiotic resource depletion	%	100	12.9	3.0	13.7	4.5	1.5	1.1	2.2	3.5	57.1	1.1	-0.3
	kg Sb eq	4.09	0.53	0.12	0.56	0.18	0.06	0.04	0.09	0.14	2.33	0.04	-0.01
Global warming (GWP100)	%	100	13.2	2.8	13.1	3.3	0.7	1.0	2.3	4.5	56.1	1.8	1.1
	kg CO_2 eq	559	74	16	74	19	4	6	13	25	314	10	6
Ozone layer depletion (ODP)	%	100	5.5	11.7	21.5	1.0	1.6	0.3	6.3	0	18.4	0.3	33.3
	kg CFC-11 eq	0.00004	0	0.00001	0.00001	0	0	0	0	0	0.00001	0	0.00001
Photochemical oxidation	%	100	7.1	4.1	14.0	9.3	1.7	0.3	1.5	36.8	16.6	2.8	5.7
	kg C_2H_2	0.048	0.003	0.002	0.007	0.004	0.001	0	0.001	0.018	0.008	0.001	0.003
Acidification	%	100	19.5	3.3	19.2	8.2	1.5	0.8	2.3	3.0	41.7	0.8	-0.2
	kg SO_2 eq	3.13	0.61	0.10	0.60	0.26	0.05	0.02	0.07	0.09	1.31	0.02	-0.01
Eutrophication	%	100	10.2	1.6	37.7	2.1	1.2	0.6	3.0	0	30.1	13.5	0.1
	kg PO_4 eq	0.334	0.034	0.005	0.126	0.007	0.004	0.002	0.010	0	0.101	0.045	0
Human toxicity	*%*	*100*	*4.4*	*3.8*	*9.4*	*0.6*	*25.1*	*1.0*	*2.1*	*0*	*52.7*	*1.0*	*0*
	kg 1,4-DB eq	*132*	*6*	*5*	*12*	*1*	*33*	*1*	*3*	*0*	*69*	*1*	*0*
Fresh water aquatic ecotox.	*%*	*100*	*2.4*	*8.6*	*7.3*	*0.2*	*0.7*	*1.4*	*2.6*	*0*	*73.3*	*1.4*	*2.0*
	kg 1,4-DB eq	*11.40 400**	*0.27*	*0.98*	*0.83*	*0.02*	*0.08*	*0.16*	*0.30*	*0*	*8.35*	*0.16*	*0.23*
Terrestrial. ecotoxicity	*%*	*100*	*4.7*	*3.8*	*19.8*	*2.2*	*0.3*	*1.2*	*2.0*	*0*	*64.2*	*1.2*	*0.6*
	kg 1,4-DB eq	*1.53*	*0.07*	*0.06*	*0.30*	*0.03*	*0.00*	*0.02*	*0.03*	*0*	*0.98*	*0.02*	*0.01*

Note: italics indicate less well developed impact methodologies

* The methodology for fresh water aquatic ecotoxicity is not well developed and does not include characterisation factors for many detergent chemicals that are likely to pass through waste water treatment works unchanged. Work conducted by Procter and Gamble and CML (Jeroen Guinee and Arjan de Koning) suggest that the toxicity loading that would arise per wash would amount to 1.49 kg 1,4-dichlorobenzene eq (DCBeq). This would result in the aquatic toxicity increasing to more than 400 kg 1,4-dichlorobenzene for the nappy use system. Detergent use would therefore contribute 100% of the life cycle aquatic toxicity impact.

The following nine tables identify which of the individual environmental burdens are responsible for the impact values above.

Table 8.14 Global warming

Substance	Flow	Percentage of Total Impact
N_2O	Air	1.1
Methane	Air	8.3
CO_2 (fossil)	Air	22.7
CO_2	Air	67.9
Remaining substances		0.0

Table 8.15 Ozone depletion

Substance	Flow	Percentage of Total Impact
HCFC-22	Air	1.1
CFC-114	Air	1.1
Tetrachloromethane	Air	2.6
Methyl chloride	Air	3.0
1,1,1-trichloroethane	Air	4.3
CFC-12	Air	27.7
HALON-1301	Air	59.9
Remaining substances		0.3

Table 8.16 Acidification

Substance	Flow	Percentage of Total Impact
Ammonia	Air	1.36
SO_2	Air	3.39
NO_x	Air	7.8
NO_x (as NO_2)	Air	17.8
SO_x	Air	18.6
SO_x (as SO_2)	Air	51.0
Remaining substances		0.03

Table 8.17 Abiotic resource depletion

Substance	Flow	Percentage of Total Impact
Crude oil	Raw	13.6
Natural gas	Raw	31.1
Coal	Raw	54.3
Remaining substances	Raw	1.1

Table 8.18 Eutrophication

Substance	Flow	Percentage of Total Impact
Nitrogen	Water	1.1
P	Water	2.25
Ammonia	Air	2.79
Phosphate	Water	9.6
COD	Water	40.1
NO_x (as NO_2)	Air	43.5
Remaining substances		0.685

Table 8.19 Photochemical oxidation

Substance	Flow	Percentage of Total Impact
Formaldehyde	Air	1.5
Ethene	Air	5.1
SO_2	Air	8.8
Methane	Air	27.3
CO	Air	53.7
Remaining substances		3.5

Table 8.20 Human toxicity

Substance	Flow	Percentage of Total Impact
NOx (as NO_2)	Air	1.0
As	Air	1.3
Se	Water	1.6
PAHs	Water	1.6
Benzene	Air	1.7
Ni	Air	7.3
Ba	Water	9.0
PAHs	Air	12.4
Other metals	Air	20.4
HF	Air	40.6
Remaining substances		3.0

Table 8.21 Fresh water aquatic ecotoxicity*

Substance	Flow	Percentage of Total Impact
Ni	Air	1.5
PAHs	Water	1.8
V	Air	2.4
Zn	Water	2.5
V	Water	3.0
Metals	Air	3.1
Cu	Water	12.3
Ni	Water	29.7
Ba	Water	38.1
Remaining substances		5.5

* The methodology for fresh water aquatic ecotoxicity is not well developed and does not include characterisation factors for many detergent chemicals that are likely to pass through waste water treatment works unchanged. Work conducted by Procter and Gamble and Leiden University (Jeroen Guinee and Arjan de Koning) suggest that the toxicity loading that would arise per wash would amount to 1.49 kg 1,4-dichlorobenzene eq (DCBeq). This would result in the aquatic toxicity increasing to more than 400 kg 1,4-dichlorobenzene for the nappy use system. Detergent use would therefore contribute 100% of the life cycle aquatic toxicity impact.

Table 8.22 Terrestrial ecotoxicity

Substance	Flow	Percentage of Total Impact
Ni	Air	2.2
V	Air	7.0
Hg	Air	36.9
Metals	Air	52.6
Remaining substances		1.3

8.3 Commercial laundry

Table 8.23 details the impact assessment for the commercial laundry nappy systems. Energy use at the laundry is the most significant contributor to the impacts assessed, vehicle use in the delivery and collection of nappies is also a significant contributor. Prefold nappy manufacture is significantly higher than terry nappy manufacture in the home use scenario. Prefold manufacture is analysed in *Table 8.33*.

Table 8.23 Impact profile - commercial laundry (Mixed Scenario: 1 child, 2.5 years)

Impact Category	Unit	Total	Prefold nappy manufacture	Wraps	Liners	Laundry Detergent	Perborate	Sodium hypochlorite	Neutra-liser	Heat gas	Electricity	Laundry vehicles	Home care	Mains water	Sewage treatment
Abiotic resource depletion	%	100	16.2	1.0	3.2	1.0	0.5	0.1	0	36.7	27.2	8.5	4.0	0.8	0.8
	kg Sb eq	5.76	0.94	0.06	0.18	0.06	0.03	0.01	0	2.11	1.56	0.49	0.23	0.05	0.05
Global warming (GWP100)	%	100	18.4	1.3	2.4	0.9	0.5	0.1	0	31.3	27.6	9.8	5.4	0.8	1.4
	kg CO_2 eq	762	140	10	19	7	4	1	0	238	210	75	41	6	11
Ozone layer depletion (ODP)	%	100	70.0	0.1	0.5	1.2	0.6	0.7	0.3	2.4	6.6	0	17.2	0.2	0.2
	kg CFC-11 eq	0.00008	0.00006	0	0	0	0	0	0	0	0.00001	0	0.00001	0	0
Photochemical oxidation	%	100	8.0	3.8	9.2	1.9	3.0	0.1	0	13.7	11.0	36.7	9.6	0.3	2.9
	kg C_2H_2	0.049	0.004	0.002	0.004	0.001	0.001	0	0	0.007	0.005	0.018	0.005	0	0.001
Acidification	%	100	34.2	3.1	8.4	1.5	1.1	0.3	0.1	8.7	28.7	7.0	5.2	0.8	0.8
	kg SO_2 eq	3.05	1.04	0.10	0.26	0.04	0.03	0.01	0	0.27	0.87	0.21	0.16	0.03	0.03
Eutrophication	%	100	20.9	0.6	2.5	1.0	1.0	0.2	0	10.9	24.6	0	20.4	0.7	17.1
	kg PO_4 eq	0.275	0.058	0.002	0.007	0.003	0.003	0	0	0.030	0.068	0	0.056	0.002	0.047
Human toxicity	*%*	*100*	*26.5*	*0.1*	*0.6*	*1.3*	*0.3*	*0.2*	*0.1*	*20.9*	*37.7*	*4.7*	*5.5*	*1.1*	*1.1*
	kg 1,4-DB eq	*123*	*33*	*0*	*1*	*2*	*0*	*0*	*0*	*26*	*47*	*6*	*7*	*1*	*1*
Fresh water aquatic ecotox.	*%*	*100*	*35.1*	*0.1*	*0.2*	*2.7*	*0.2*	*0.2*	*0.1*	*1.7*	*48.1*	*0.4*	*8.2*	*1.4*	*1.4*
	kg 1,4-DB eq	*11.60* *100**	*4.09*	*0.01*	*0.02*	*0.32*	*0.03*	*0.03*	*0.01*	*0.20*	*5.60*	*0.04*	*0.96*	*0.16*	*0.17*
Terrestrial. ecotoxicity	*%*	*100*	*58.9*	*0.1*	*1.2*	*0.4*	*0.1*	*0.3*	*0.1*	*8.2*	*24.4*	*0.6*	*4.2*	*0.7*	*0.7*
	kg 1,4-DB eq	*2.70*	*1.59*	*0.00*	*0.03*	*0.01*	*0*	*0.01*	*0*	*0.22*	*0.66*	*0.02*	*0.11*	*0.02*	*0.02*

Note: italics indicate less well developed impact methodologies

*The methodology for fresh water aquatic ecotoxicity is not well developed and does not include characterisation factors for many detergent chemicals that are likely to pass through waste water treatment works unchanged. Work conducted by Procter and Gamble and Leiden University (Jeroen Guinee and Arjan de Koning) suggest that the toxicity loading that would arise per wash would amount to 2.19 kg 1,4-dichlorobenzene eq (DCBeq) per laundry wash and 1.49 kg 1,4-dichlorobenzene eq (DCBeq) per home wash . This would result in the aquatic toxicity increasing to more than 100 kg 1,4-dichlorobenzene for the nappy use system. Detergent use would therefore contribute more than 90% of the life cycle aquatic toxicity impact.

The following nine tables identify which of the individual environmental burdens are responsible for the impact values above.

Table 8.24 Global warming

Substance	Flow	Percentage of Total Impact
CO_2 (fossil)	Air	4.2
Methane	Air	6.8
CO_2	Air	88.4
Remaining substances		0.7

Table 8.25 Ozone depletion

Substance	Flow	Percentage of Total Impact
1,1,1-trichloroethane	Air	2.0
CFC-12	Air	12.6
HALON-1301	Air	84.1
Remaining substances		1.3

Table 8.26 Acidification

Substance	Flow	Percentage of Total Impact
NO_x	Air	26.5
SO_x	Air	73.1
Remaining substances		0.4

Table 8.27 Abiotic resource depletion

Substance	Flow	Percentage of Total Impact
Crude oil	Raw	18.6
Coal	Raw	23.6
Natural gas	Raw	54.7
Remaining substances	Raw	3.1

Table 8.28 Eutrophication

Substance	Flow	Percentage of Total Impact
P	Water	1.8
Phosphate	Water	8.5
COD	Water	33.2
NO_x (as NO_2)	Air	54.0
Remaining substances		2.5

Table 8.29 Photochemical oxidation

Substance	Flow	Percentage of Total Impact
Ethene	Air	1.5
Benzene	Air	2.5
Ethylbenzene	Air	2.7
Formaldehyde	Air	3.8
Pentane	Air	4.8
Toluene	Air	10.1
SO_2	Air	11.9
Methane	Air	30.0
CO	Air	31.3
Remaining substances		1.5

Table 8.30 Human toxicity

Substance	Flow	Percentage of Total Impact
NO_x (as NO_2)	Air	1.1
Hg	Water	1.7
PAHs	Water	3.7
Ba	Water	8.3
Benzene	Air	8.6
HF	Air	11.7
Ni	Air	15.2
Metals	Air	18.7
PAHs	Air	28.3
Remaining substances		2.8

Table 8.31 Fresh water aquatic ecotoxicity*

Substance	Flow	Percentage of Total Impact
V	Water	1.1
Zn	Water	2.0
Metals	Air	2.6
Ni	Air	2.9
PAHs	Water	3.9
Cu	Water	9.1
Ni	Water	20.9
Hg	Water	21.9
Ba	Water	31.9
Remaining substances		3.8

*The methodology for fresh water aquatic ecotoxicity is not well developed and does not include characterisation factors for many detergent chemicals that are likely to pass through waste water treatment works unchanged. Work conducted by Procter and Gamble and Leiden University (Jeroen Guinee and Arjan de Koning) suggest that the toxicity loading that would arise per wash would amount to 2.19 kg 1,4-dichlorobenzene eq (DCBeq) per laundry wash and 1.49 kg 1,4-dichlorobenzene eq (DCBeq) per home wash . This would result in the aquatic toxicity increasing to more than 100 kg 1,4-dichlorobenzene for the nappy use system. Detergent chemicals would therefore contribute more than 90% of the life cycle aquatic toxicity impact.

Table 8.32 Terrestrial ecotoxicity

Substance	Flow	Percentage of Total Impact
Ni	Air	2.4
Hg	Air	19.0
Metals	Air	25.6
Hg	Water	51.7
Remaining substances		1.3

8.3.1 Prefold nappy production – commercial laundry

Table 8.33 details the impact assessment for prefold nappy manufacture. Electricity use in fabric production dominates the impact contribution from prefold manufacture.

Table 8.33 Impact profile – prefold nappy manufacture

Impact Category	Unit	Total	Cotton lint production	Hydrogen peroxide	Electricity	Heat gas	Transport	Surface water emissions	Sewage treatment
Abiotic resource depletion	%	100	4.1	1.1	85.7	8.6	0.5	0	0
	kg Sb eq	0.935	0.038	0.010	0.801	0.081	0.005	0	0
Global warming (GWP100)	%	100	3.8	1.0	88.1	6.5	0.5	0	0
	kg CO_2 eq	140.3	5.4	1.5	123.7	9.1	0.8	0	0.1
Ozone layer depletion (ODP)	%	100	0.9	0.4	97.5	0.1	1.1	0	0
	kg CFC-11 eq	0.00006	0	0	0.00006	0	0	0	0
Photochemical oxidation	%	100	25.7	7.0	58.9	6.6	1.7	0	0.2
	kg C_2H_2	0.00390	0.00100	0.00027	0.00230	0.00026	0.00007	0	0.00001
Acidification	%	100	5.0	0.7	92.4	1.0	1.0	0	0
	kg SO_2 eq	1.04	0.05	0.01	0.96	0.01	0.01	0	0
Eutrophication	%	100	32.5	0.8	58.1	2.0	1.7	4.5	0.4
	kg PO_4 eq	0.057	0.019	0	0.033	0.001	0.001	0.003	0
Human toxicity	*%*	*100*	*0.9*	*0.8*	*88.0*	*3.0*	*0.8*	*6.4*	*0*
	kg 1,4-DB eq	*32.6*	*0.3*	*0.3*	*28.7*	*1.0*	*0.3*	*2.1*	*0*
Fresh water aquatic ecotox.	*%*	*100*	*0.9*	*0.3*	*35.3*	*0.2*	*0.3*	*62.9*	*0*
	Kg 1,4-DB eq	*4.08*	*0.04*	*0.01*	*1.45*	*0.01*	*0.01*	*2.58*	*0*
Terrestrial. ecotoxicity	*%*	*100*	*0.2*	*0.2*	*11.4*	*0.5*	*0.1*	*87.7*	*0*
	Kg 1,4-DB eq	*1.59*	*0*	*0*	*0.18*	*0.01*	*0*	*1.40*	*0*

Note: italics indicate less well developed impact methodologies

9 Sensitivity analysis and normalisation

This section describes the sensitivity analysis and normalisation undertaken as part of this study. Sensitivity analysis is a process where key input parameters about which there may be uncertainty or for which a range of values may exist are deliberately varied in the modelling and shows the effect that such variation could have had on the results of the assessment. The sensitivity analyses carried out and reported here were agreed by the project board. Normalisation attempts to compare the impacts from the systems studied to the impacts of some everyday activity or to a proportion of the same impact but from a wider system.

9.1 Number of changes

The user surveys and the sales data for disposables corroborate each other in terms of changes per day. However, due to issues of clarity in the survey we have assessed a lower use figure, 4.05 changes per day. *Figure 9.1* shows the implication of this change.

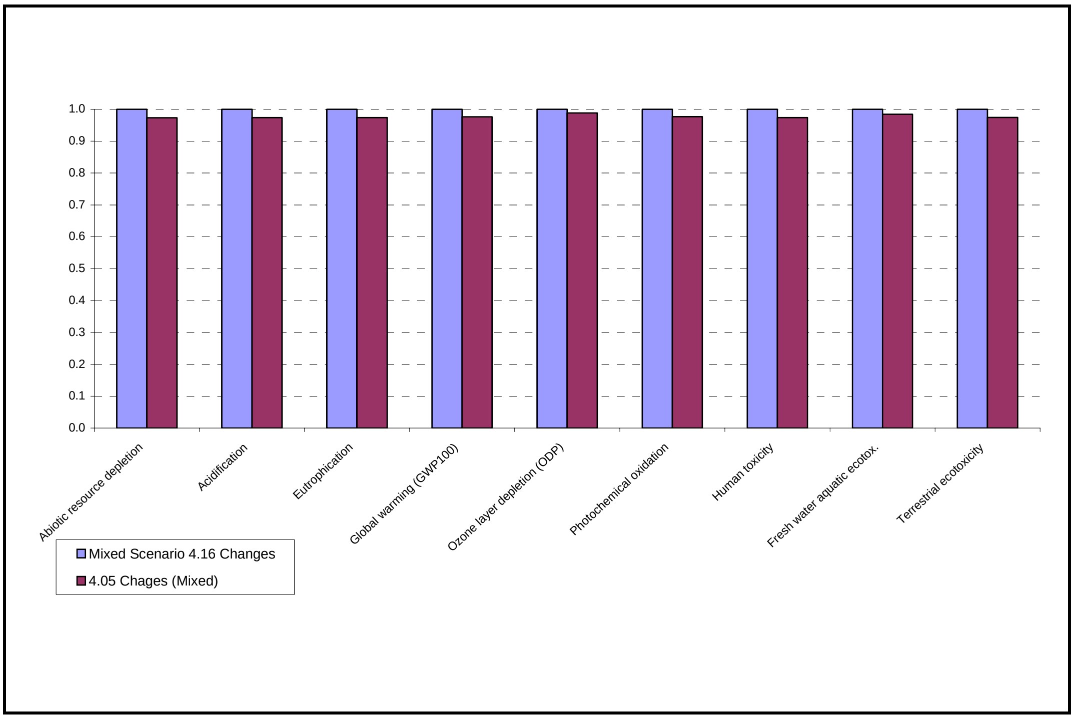


Figure 9.1 Normalised comparison of 4.05 changes with 4.16 changes

9.2 Omitted materials manufacture

Although small in mass, we have assessed the implication of the assumption to exclude minor inputs. We have done this by including an equivalent amount of super absorbent polymer. *Figure 9.2* shows the implication of this change.

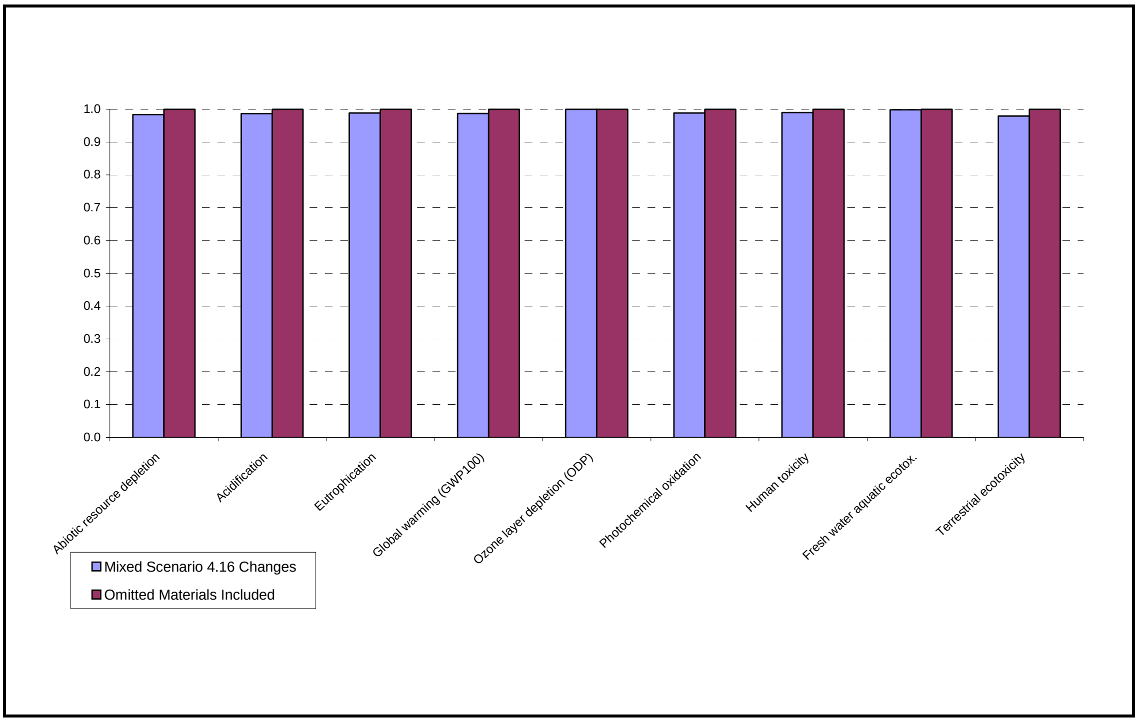


Figure 9.2 Normalised comparison: omitted material sensitivity

9.2.1 Disposal assumptions

A significant assumption in the study is the use of *WISARD* data for the disposal of excreta. We have assumed that the excreta contained in the nappies is putrescible waste, and that the waste management burdens are the same as those for the disposal of putrescible waste. This approach has, in our opinion, overestimated the burden associated with waste disposal, as the majority of the excreta is water. To assess this assumption, we removed putrescible waste management from the system. *Figure 9.3* shows the implications of this change. This change results in a significant reduction (greater than 10 per cent) in the ozone depletion, eutrophication and photochemical smog impacts.

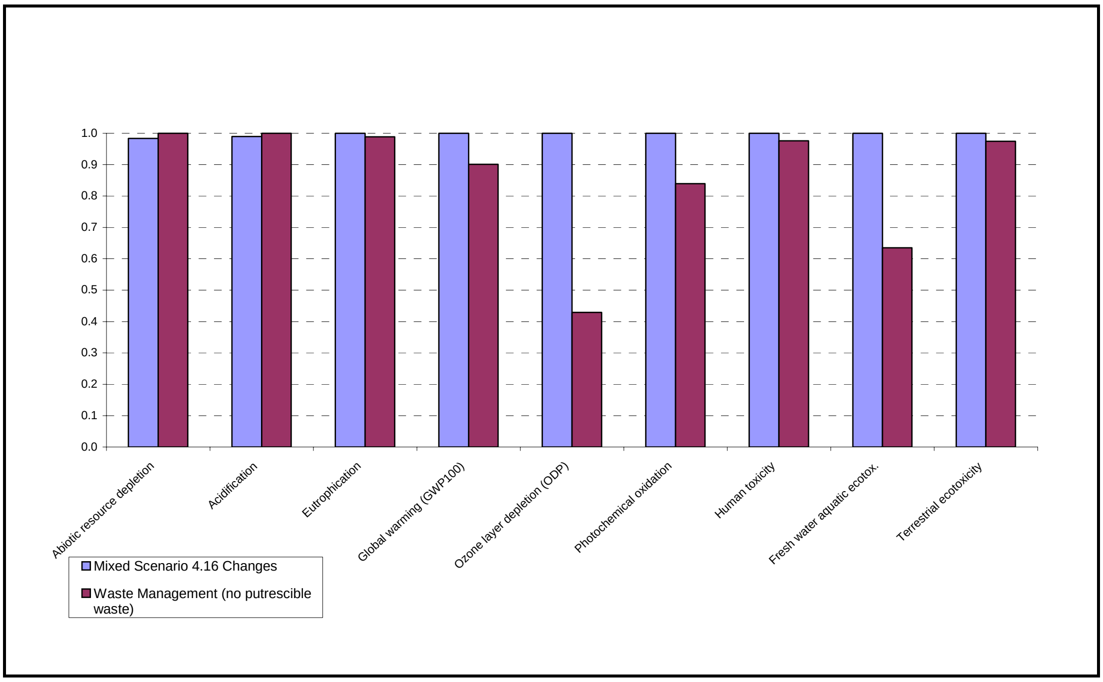


Figure 9.3 Normalised comparison: waste management sensitivity

9.2.2 Chemical oxygen demand

On analysis of the *WISARD* life cycle tool, it is believed that the COD emissions is under reported, as it is impossible for COD emission to be lower than BOD emission. To test the significance of this error, we have assessed a COD emission that is equivalent to the BOD emission from end of life. This change results in a 6 per cent increase in the eutrophication impact, no change occurs to other impacts.

9.3 Sensitivity of the reusable nappies home use system

9.3.1 Tumble drying

There is a significant level of uncertainty as to the use of tumble driers for drying nappies. *Figure 9.4* shows the implication of increasing tumble drying from 19 per cent (baseline) of washes to 60 per cent of washes. This is an ERM estimate based on family tumble drier ownership being between 65 per cent and 74 per cent of families (ONS, 2002). The group for efficient appliance suggest an average tumble drier activity of 60 per cent compared with washing (GEA, 1995). This a Europe-wide report and does not reflect families alone.

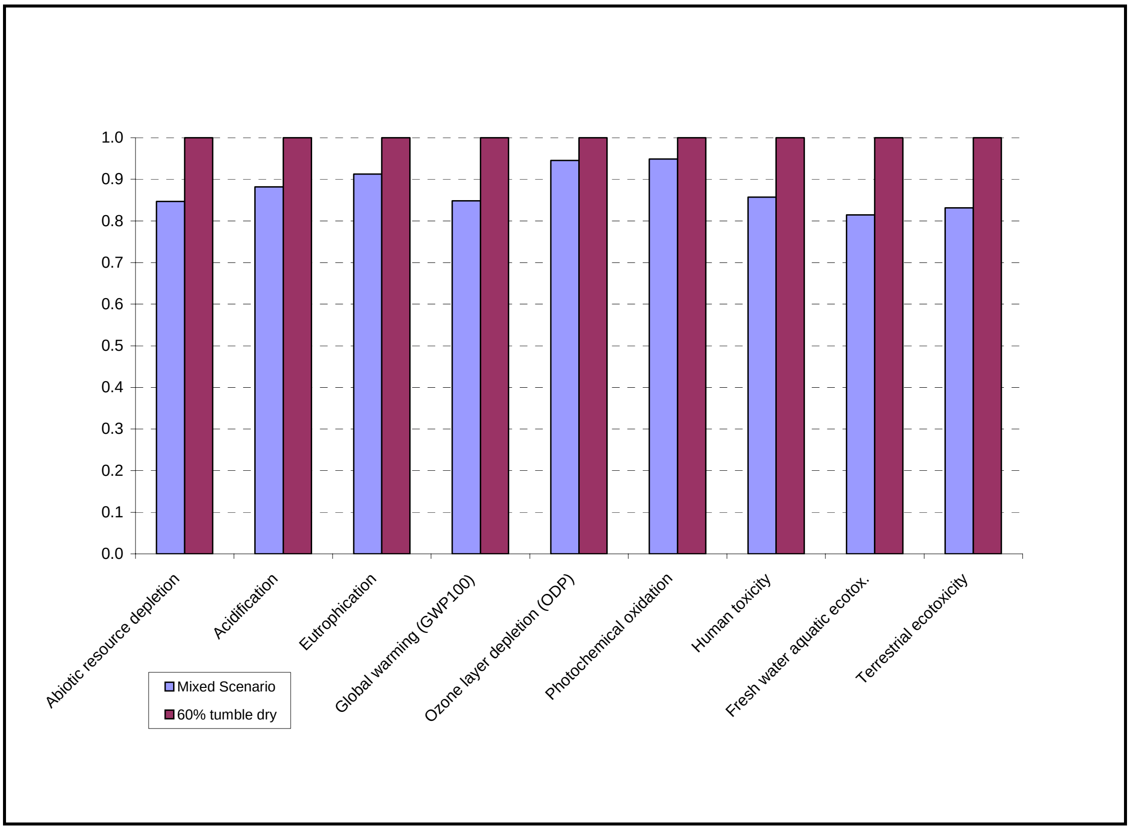


Figure 9.4 60% tumble dry

9.3.2 Electricity consumption washing

There is some uncertainty regarding washing machine electricity consumption in 2002. In the baseline model, we assumed performance of a machine sold in 1997, as washing machine life is approximately 12 years. *Figure 9.5* shows the implication of using average wash consumption data for machines sold in 2000.

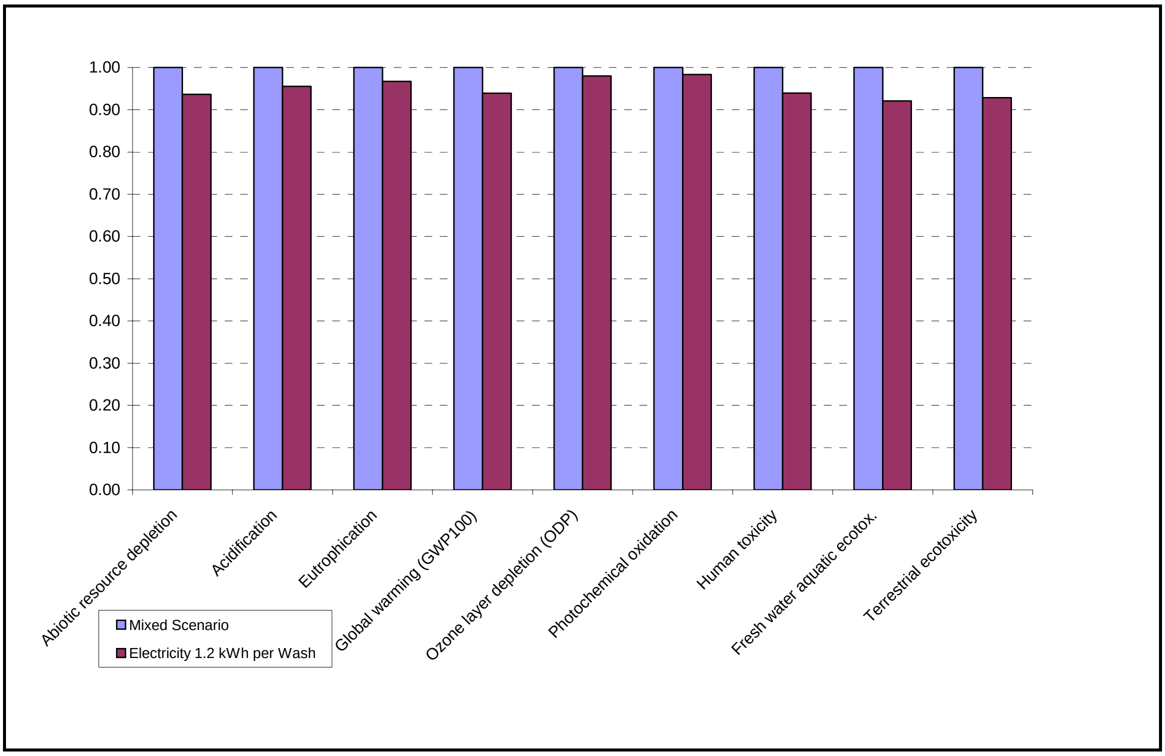


Figure 9.5 Washing machine electricity consumption

9.3.3 Omitted material manufacture

Due to the low mass of wraps and boosters entering the retail stage, their manufacture was excluded from the study*. Figure 9.6* shows the implication of including these products. For boosters, we used terry manufacture as being analogous to booster manufacture. For wraps/pants, we assumed PVC as this was the most common material for wraps (Environment Agency, 2004).

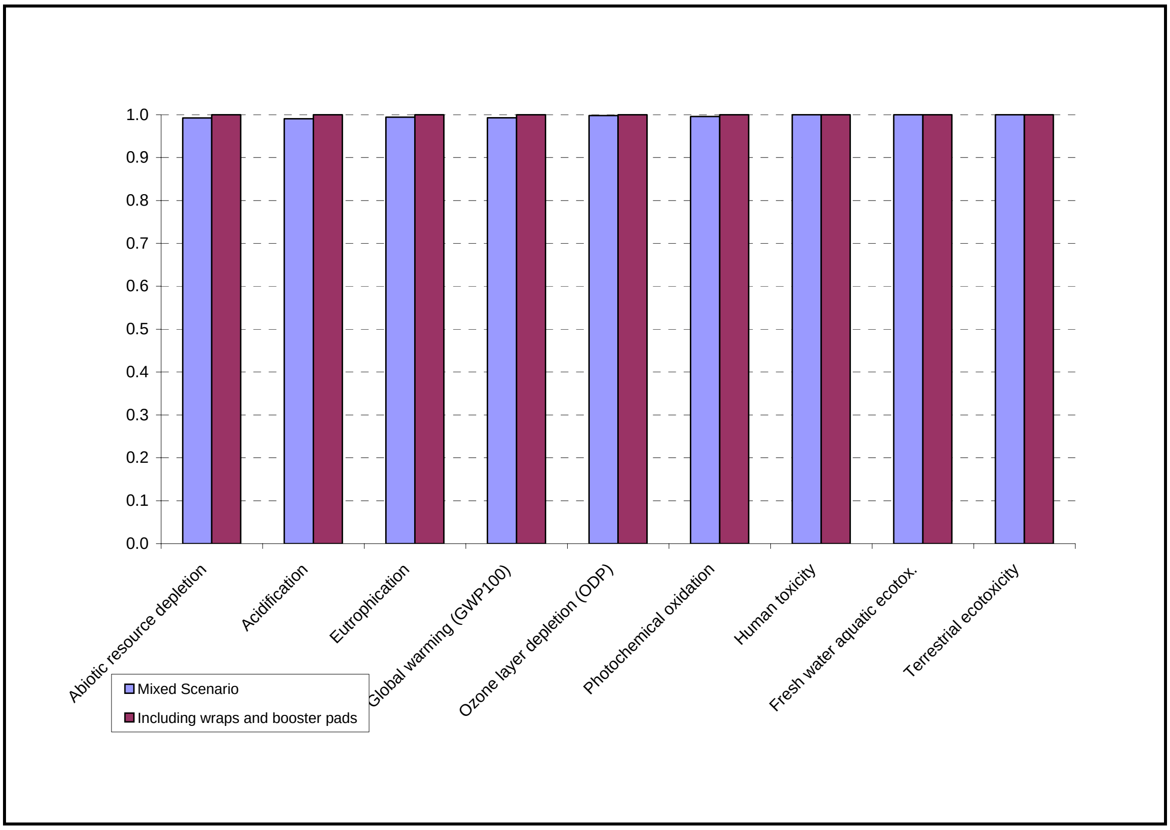


Figure 9.6 Including boosters and wraps

9.3.4 Liner disposal

There is a high level of uncertainty as to how used liners are disposed. In this study we have assumed that 86 per cent of users consume one liner per nappy change and that 50 per cent are flushed and 50 per cent disposed to household bin. *Figure 9.7* shows the implication of flushing all liners. With the exception of the ozone depletion impact no significant difference (greater than 10 per cent) is observed.

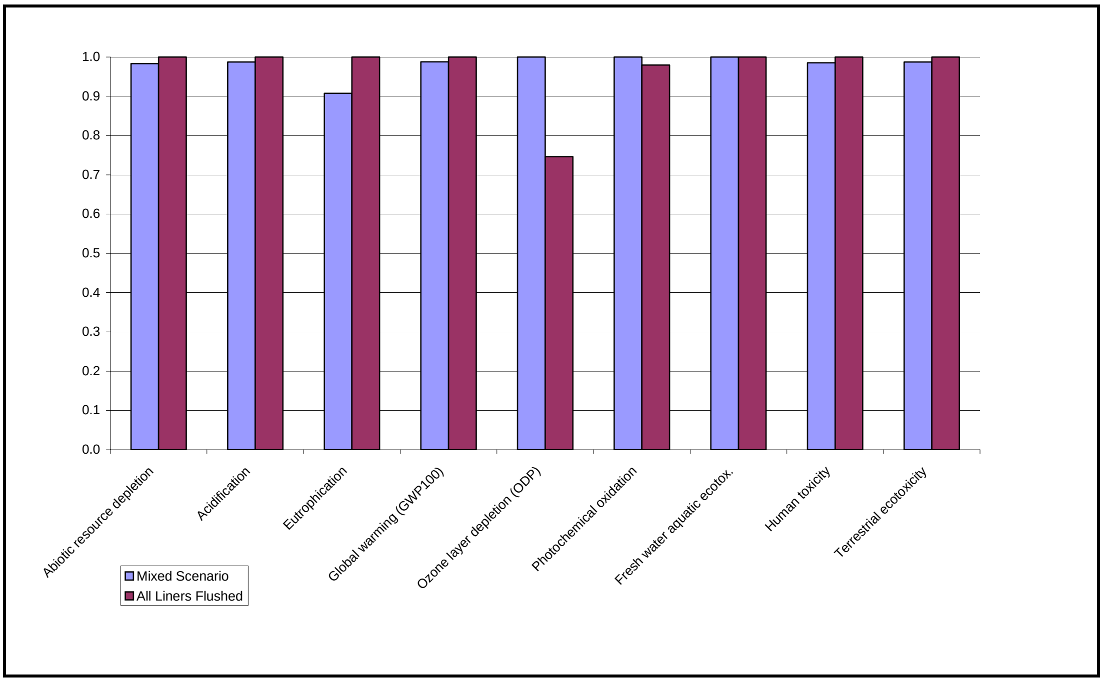


Figure 9.7 Liner disposal sensitivity

9.3.5 Number of nappies owned, previous use and waste management

It was difficult to determine actual numbers of nappies purchased per child over the 2.5 years from the surveys. The ERM sales survey found that at least 750,000 reusable nappies were sold in 2001-2002. Based on the reusable nappy wearing population, this would suggest a minimum of 30 nappies purchased over the 2.5 years. Using the same calculation method for terry nappies, the minimum purchased is calculated to be 43 nappies over the 2.5 years.

We have used a figure of 47.5 for the terry system in the study, based on minimum ownership in any one six month period. This is considered to be a weak assumption based on the limited number of responses, however it is considered a reasonable assumption based on the sales survey.

We have not allocated any disposal burden for terry nappies to the system, as nappies tend to be reused for other purposes within the home, including use on another child. There is a high level of uncertainty associated with this assumption. However, when considering the mass involved it is not considered significant.

9.3.6 Nappy type

The study reflects home use of the most popular reusable nappies, terry nappies. The environmental impacts associated with other nappy types such as prefold and shaped will be of a similar scale to the terry nappy system assessed. Although ownership patterns are likely to be different, due to cost, engineering and size differentiation.

9.3.7 Aquatic toxicity

The methodology for fresh water aquatic ecotoxicity is not well developed and does not include characterisation factors for many detergent chemicals that are likely to pass through waste water treatment works unchanged. Work conducted by Procter and Gamble and Leiden University (Jeroen Guinee and Arjan de Koning) suggest that the toxicity loading that would arise per wash would amount to 2.19 kg 1,4-dichlorobenzene eq (DCBeq) per laundry wash and 1.49 kg 1,4-dichlorobenzene eq (DCBeq) per home wash. This would increase the aquatic toxicity impact value to over 400 kg 1,4-dichlorobenzene equivalents for the terry nappy system. This is a massive increase in this impact burden. The new characterisation factors that have been developed by CML are to be published later this year.

9.4 Sensitivity of the commercial laundry system

9.4.1 Prefold nappy manufacture (includes raw materials, energy generation and transport to the UK)

Prefold nappy manufacture is a surprising contributor to the impact profile of the commercial laundry system. The majority of the impact contribution is associated with energy consumption, in particular electricity generation. Prefold manufacture from lint to nappy consumes 61,653 kWh of fuel/electricity input per tonne of nappies (82 per cent electricity). Terry nappy production from lint consumes approximately 23,938 kWh of fuel/electricity input per tonne of nappies (53 per cent electricity). This is a significant difference and worthy of note. The lack of data sets for prefold manufacture is a limitation of the study.

They both consume, approximately, the same amount of natural gas, and it is electricity consumption that differs. This would suggest that differences in yarn spinning, knitting/weaving processes might be the source of the difference, since spinning is a significant user of electricity.

For terry nappies we have assumed 10,000 kWh per tonne of yarn produced. This is a representative figure for spinning, although spinning mills vary markedly across the world and with the age of the technology employed. For prefold manufacture, we have used one data source (this includes all operations from lint input to final nappy output), for terry production we have used one data source for production stages post yarn spinning.

There is therefore a significant level of uncertainty with regard to this stage of the life cycle.

Figure 9.8 shows the implication of using the terry fabric manufacturing data in place of prefold manufacture. *Figure 9.8* shows that the system is sensitive to the prefold manufacturing data and suggests that the study would benefit to further work in this area.

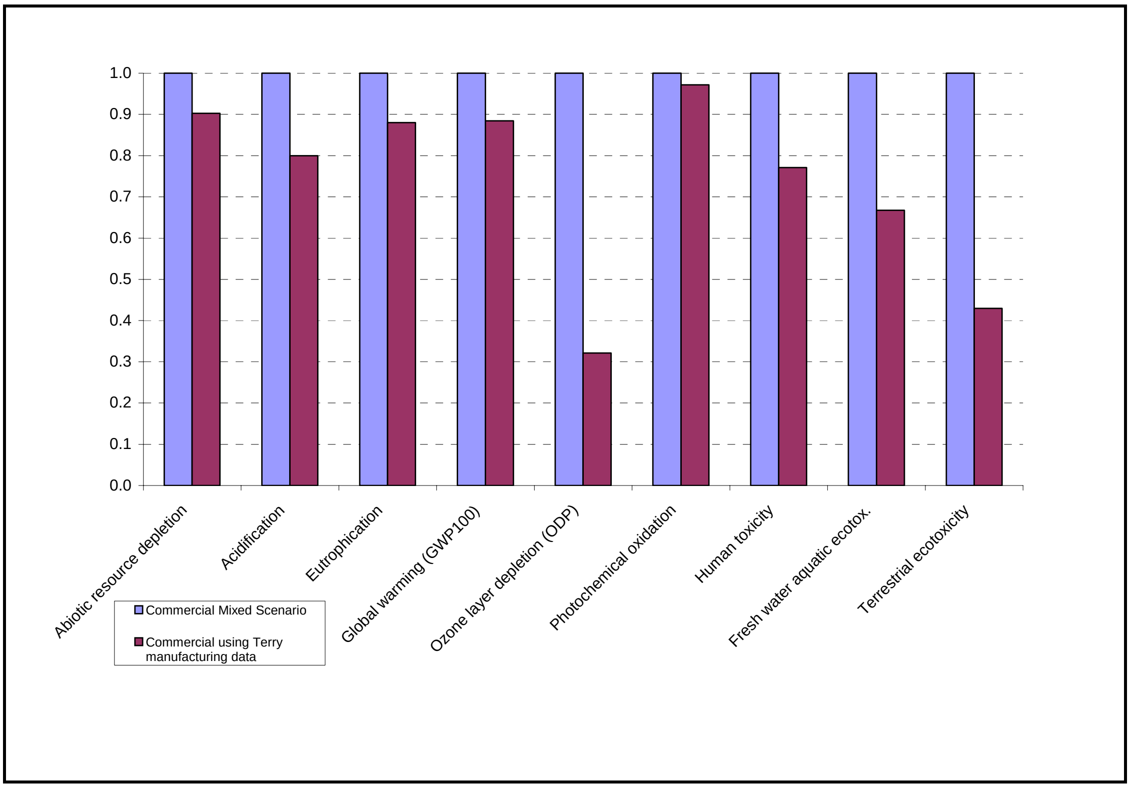


Figure 9.8 Fabric production sensitivity

9.4.2 Aquatic toxicity

The methodology for fresh water aquatic ecotoxicity is not well developed and does not include characterisation factors for many detergent chemicals that are likely to pass through waste water treatment works unchanged. Work conducted by Procter and Gamble and Leiden University (Jeroen Guinee and Arjan de Koning) suggest that the toxicity loading that would arise per wash would amount to 2.19 kg 1,4-dichlorobenzene eq (DCBeq) per laundry wash and 1.49 1,4-dichlorobenzene eq (DCBeq) per home wash. This would increase the aquatic toxicity impact value to over 100 kg 1,4-dichlorobenzene equivalents for the commercial laundry system. This is a significant increase in this impact burden. The new characterisation factors that have been developed by CML are to be published later this year.

9.5 Age of data

The data used in the study are considered a reasonable reflection of nappy use in 2001-2002. The data reflects post 1990 technology, and includes data specific for 2001-2002. All inventories for flows identified as significant in the impact assessment are considered representative of 2001. In the main, materials production, manufacturing and nappy use have been defined using data describing activities in the study year.

9.6 Retail and consumer transport – data and allocation

Due to the lack of data regarding retail and consumer transport, assumptions and estimates have been made regarding retail outlet energy use and transport to and from retail outlets. These areas have most significance for the disposable nappy system. Allocation was required to allocate retail energy use and consumer transport of nappies home. Although we believe the data and allocations to be reasonable, the data may not be representative of the UK situation as a whole.

9.7 Data quality

The quality of the data with regard to consumer use characteristics (includes number of changes) and disposable manufacturing and disposable material manufacturing are considered to be very good. There are some concerns with regard to tumble drying; washing machine performance; and reusable nappy manufacture that results in a high level of uncertainty associated with the reusable nappy systems. Though individually the reusable manufacturing data sets are considered of good quality they can not be considered to be representative of all reusable nappies.

The systems assessed, including the sensitivities, provide a robust indication as to the scale of the potential impacts associated with the nappy systems.

9.8 Functional unit

The function that was deemed appropriate to the goals of the study was defined as *"the use of nappies during the first 2.5 years of a child's life"*. This functional unit was agreed by the Project Advisory Board early on in the study.

The user surveys commissioned by the Environment Agency supported the use of 2.5 years as a functional unit.

9.9 Normalisation

The individual impact results determined in the characterisation and classification steps above are difficult to compare and to interpret because of their differing orders of magnitude. Normalisation makes the impact assessment results for each system more meaningful, by relating them to the total emissions or extractions in a certain area over a given period of time. One method would be to compare the burdens for nappy use with the impact profile for UK households in the study year. However, these figures are not available, so total European annual effect scores for 1995 (total impact values for Europe) (Hujbregts *et al.2002*) have been used for the purpose of this study. Shown in *Figure 9.9* to *Figure 9.11* are the impact burdens for the whole life cycle as a percentage of the European impact burden.

If we accept the utility of normalised impacts, then the figures identify resource consumption of the three systems as being the most significant burden, in terms of scale of contribution. However this would change if the aquatic toxicity of detergent chemicals was confirmed, aquatic toxicity would become the most significant impact for the reusable systems, if the utility of normalisation is accepted.

The abiotic resource depletion impact burden is predominantly associated with the extraction of oil, gas and coal reserves. For the reusable systems, this impact is associated with energy consumption in the care of nappies. For the disposable system, it is associated with energy and fossil resource consumption associated with the production of polymers. This highlights the significance of care characteristics for reusables and change frequency for disposables. For the commercial laundry there is less potential variability in care.

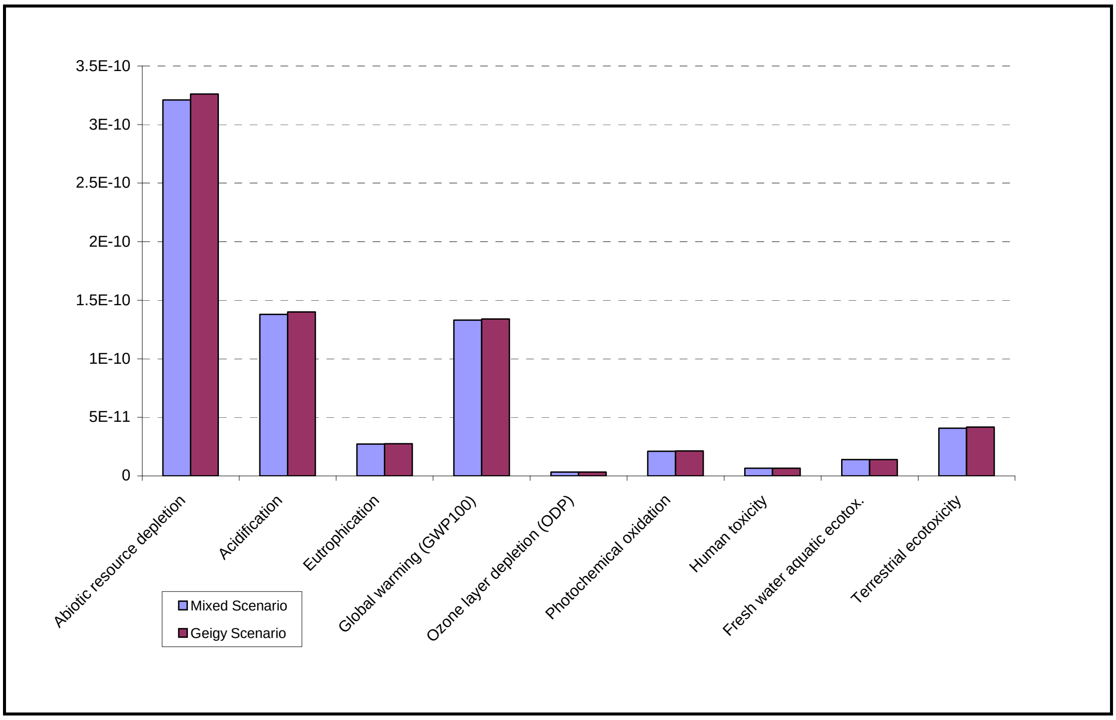


Figure 9.9 Normalisation chart for disposable nappies

The chart's scale represents the contribution of one child's use of nappies over 2.5 years to total European impacts in 1995.

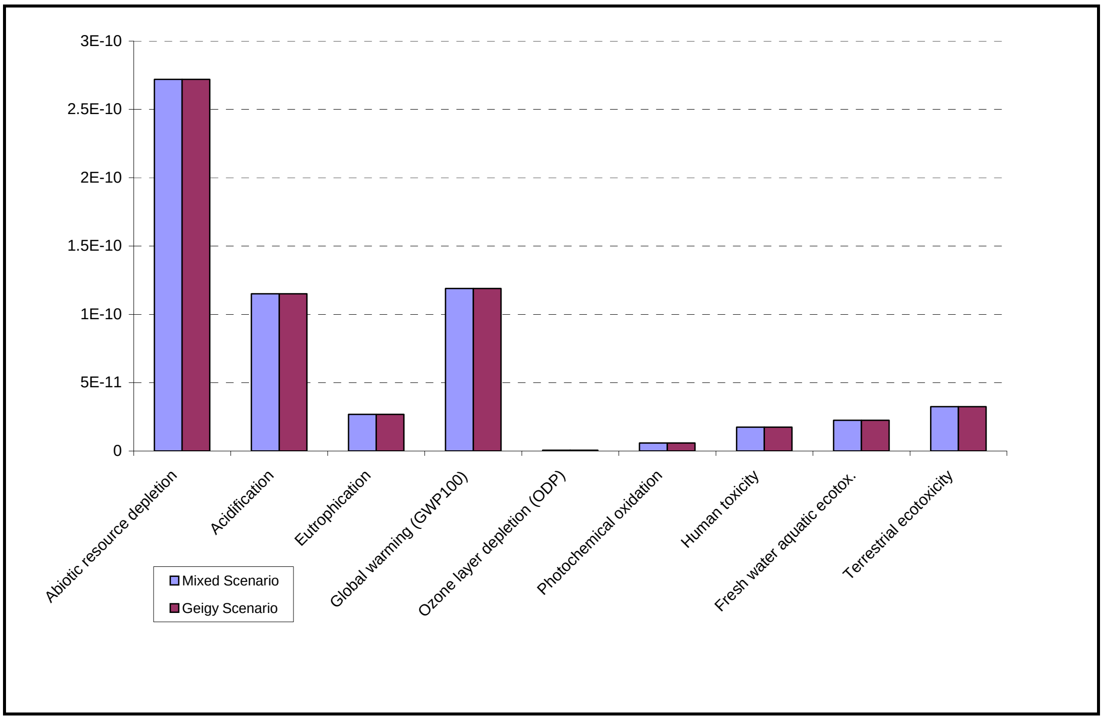


Figure 9.10 Normalisation chart for reusable nappy - home laundered

The chart's scale represents the contribution of one child's use of nappies over 2.5 years to total European impacts in 1995.

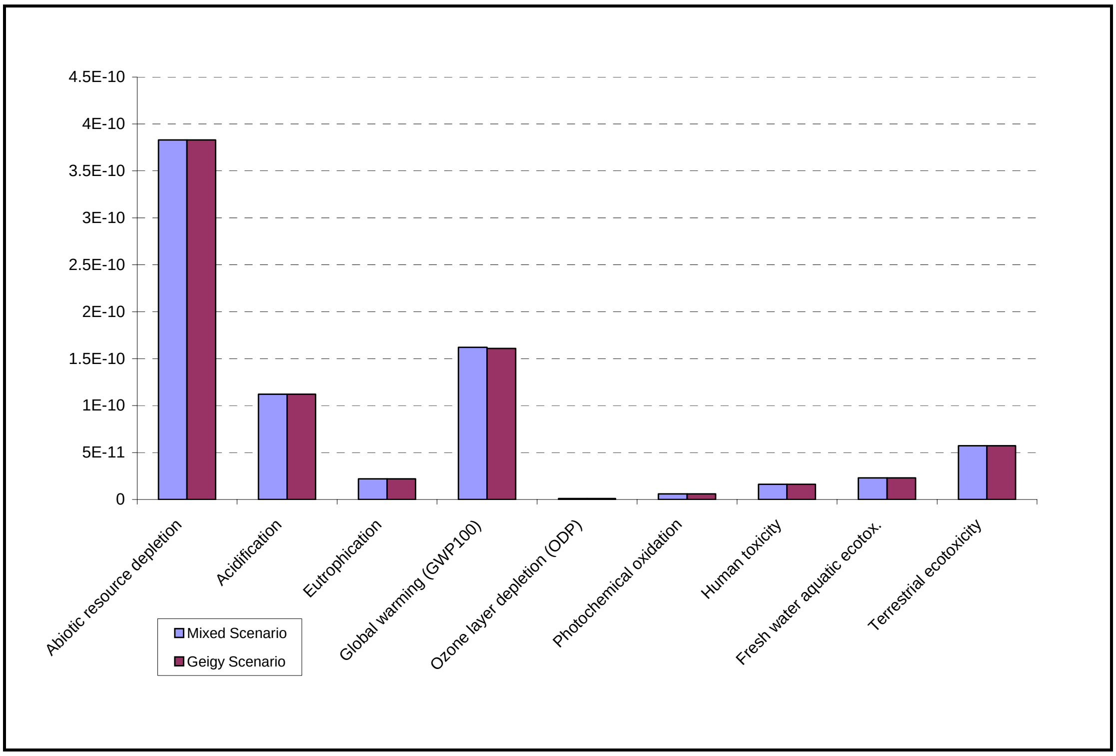


Figure 9.11 Normalisation chart for reusable nappy - commercial laundry

The chart's scale represents the contribution of one child's use of nappies over 2.5 years to total European impacts in 1995.

10 Interpretation and conclusions

There is no significant difference between any of the environmental impacts of the disposable, home use reusable and commercial laundry systems that were assessed. None of the systems studied is more or less environmentally preferable.

The following environmental impacts were agreed by the project board as those to be assessed in the study:

- global warming;
- ozone depletion
- summer smog formation (photo-oxidant formation);
- depletion of non-renewable reserves (depletion of abiotic resources);
- nutrient water pollution (eutrophication);
- acidification;
- human toxicity; and
- aquatic and terrestrial toxicity measures.

The impact burdens for each impact category have been normalised using the average impact burden across the three systems (the average, therefore, has a value of 1). *Figure 10.1* and show the similarity between the systems across all these impact categories using the impact ranges that result from the sensitivity analyses conducted. The variation in impact resulting from the sensitivity analysis is shown as a range for each impact. The analysis does not alter the overall conclusion.

For all three systems, the major impact areas, in terms of scale of contribution, have been identified as non-renewable resource depletion, acidification and global warming.

Although the impacts are very similar, the life cycle stages that are the main source for these impacts are different for each system. For the disposable nappy system, the main sources of environmental impact are raw material production and conversion of these materials into disposable nappy components, for example, fluff pulp and super absorbent polymer.

For the home laundered nappy system, the main source of environmental impact is the generation of the electricity used in washing and drying the nappies. For the commercial laundry system, the main sources of environmental impact are the fuels and electricity consumed by laundry activities.

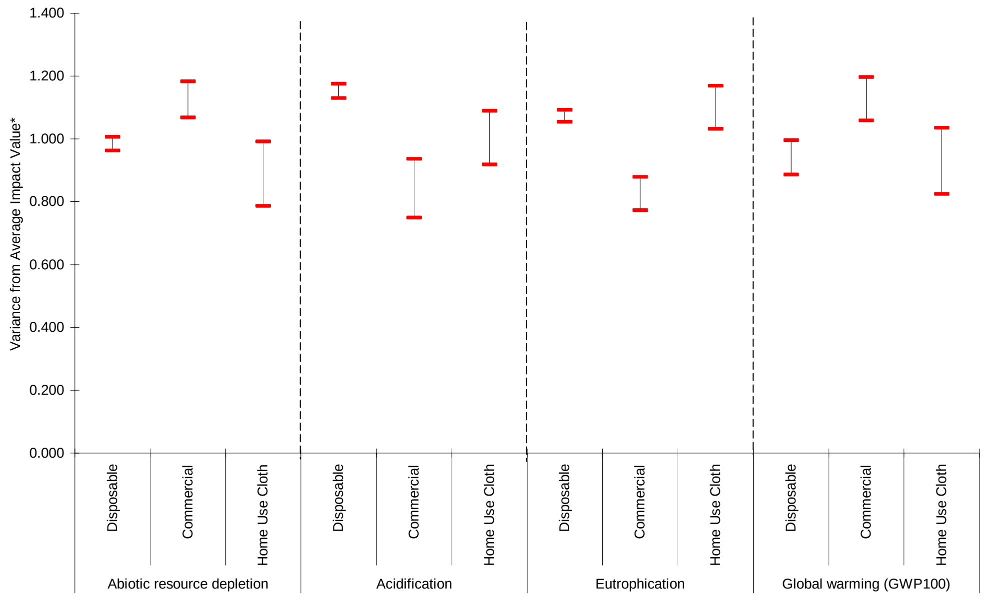
For all three systems the impacts from waste management do not contribute substantially to the overall totals, although the proportion contributed by waste management is greater for the disposable nappies system than for the two reusable systems.

Global warming and non-renewable resource depletion impacts, over the 2.5 years for which a child is assumed to be using nappies, are comparable with driving a car between 1300 and 2200 miles.

In the UK, there are over 20 million cars on the road. Consequently, the wearing of nappies by children in the UK in one year results in a global warming and non renewable resource depletion impact equivalent to the consumption and emissions of 98,600 cars each driven an average 12,000 miles.

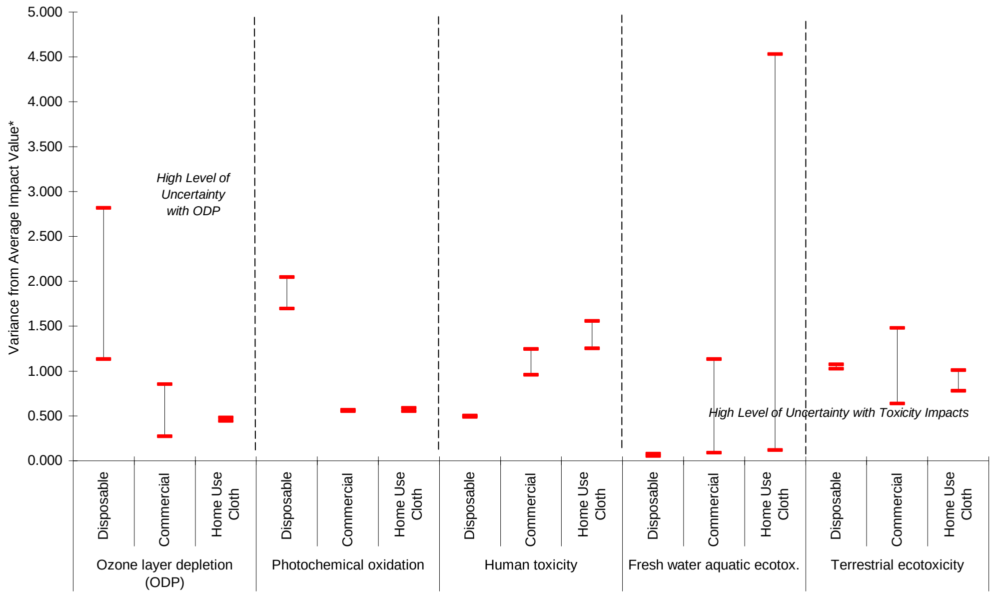
The results of the study suggest that the focus for improving the environmental performance of disposable nappies should be on the disposable nappy manufacturers and their suppliers whereas, with reusable nappies, it is the user who can achieve the most environmental gain through energy efficiency drives in the home:

- disposable nappy manufacturers should focus on weight reduction and improvements in materials manufacturing; and
- reusable users should focus on reducing energy consumed in washing and drying.



*Calculated:
(Low pt. of range system X ÷ Average systems X,Y,Z) - (High pt of range system X ÷ Average systems X,Y,Z)

Figure 10.1 Sensitivity analysis of the three systems (normalised using average impact value for all systems)



*Calculated:
(Low pt. of range system X ÷ Average systems X,Y,Z) - (High pt of range system X ÷ Average systems X,Y,Z)

Figure 10.2 Sensitivity analysis of the three systems (normalised using average (impact value for all systems)

10.1 Recommendations for further work

The study reports on the performance of the dominant nappy systems in use in 2001-2002. The study does not address what future developments may take place in disposable or reusable nappy systems. However, the study has been supported by a stakeholder group representing the interested parties and is the most comprehensive, independent study of its kind. Therefore, if products which were not studied become dominant in the market, or new products are developed, or changes are made to the existing dominant products which significantly reduce their impacts, then this study should be used as the basis for any further studies comparing the impacts of different types of disposable or reusable nappies.

Although not critical to the conclusions of the work, there are a number of areas where the study would benefit from further analysis and development. These areas were tested through sensitivity analysis in order to determine their significance.

The aquatic toxicity impact assessment method is a developing approach. As further research is published, a more accurate assessment will be possible.

The study could be improved with more data sets for the manufacture of cloth nappies. However, this element of the life cycle is not the main source of environmental impact for the reusable systems.

The surveys conducted to determine consumer behaviour provided essential data relating to the use of nappies and were invaluable to the study. However, the amount of analysis and quality of the results might be improved with a larger sample and by refining the questions.

For the disposable nappy system, assumptions about excreta generation and its disposal have a significant effect on the ozone depletion impact. This is believed to be overestimated due to the allocation of emissions of CFCs from landfill on the basis of input mass, and not on the composition of the waste.

There was limited amount of data regarding the quantities of excreta that are generated by children. Further research in this area may increase the precision of the study.

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Glossary of life cycle inventory sources

APME: *Association of Plastics Manufacturers in Europe. The Ecoprofiles (Life Cycle Inventories) can be obtained at www.apme.org.*

BUWAL 250: *Environmental. Series No. 250/1, Swiss Agency for the Environment, Forests and Landscape (SAEFL) Berne, 1998*

EDANA: *European Disposables and Nonwovens Association, Avenue Eugène Plasky, 157, 1030 Brussels – Belgium. Life Cycle Inventories, provided to ERM 2003.*

EMPA: *Swiss Federal. Laboratories for Material.s Testing and Research. Life Cycle Inventories for the Production of Detergent Ingredients – EMPA-Bericht Nr. 244.*

FAL: *The Franklin Associates Life Cycle Inventory database, Franklin Associates, Prairie Village, Kansas, USA.*

IDEMAT: *Delft University of Technology, Faculty of Design, Engineering and Production, Design for Sustainability Program.*

SimaPro 5.1: *SimaPro LCA software, PRé Consultants bv · Plotterweg 12 · 3821 BB Amersfoort · The Netherlands. The software can be obtained at www.pre.nl.*

WISARD: *Waste - Integrated Systems for Assessment of Recovery and Disposal.; the Environment Agency's life cycle software for waste management. Version 3.3.*

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Annex A

Life Cycle Inventories

Table A1 Life cycle inventories for the three nappy systems (extracted from the SimaPro software model)

Substance	Compartment	Unit	Terry Mixed Scenario	Terry Geigy Scenario	Commercial Laundry Mixed Scenario	Commercial Laundry Geigy Scenario	Disposable Use Mixed Scenario	Disposable Use Geigy Scenario
additions	Resource	kg	0.00000161	0.00000161	0.0000134	0.0000134	1.47	1.47
air	Resource	kg	x	x	x	x	36.6	36.6
artificial fertilizer	Resource	kg	0.00354	0.00354	x	x	0.0408	0.0408
barium (in ore)	Resource	kg	0.00000561	0.00000561	0.00000574	0.00000574	0.0000731	0.0000432
barrage water	Resource	kg	x	x	26.7	26.7	16.6	16.6
baryte	Resource	kg	0.00476	0.00476	0.00207	0.00207	0.0265	0.0265
bauxite	Resource	kg	3.28	3.28	0.437	0.437	0.167	0.166
bentonite	Resource	kg	0.00253	0.00253	0.00114	0.00114	0.0187	0.0166
biogas	Resource	m3	0.000782	0.000782	x	x	0.00968	0.00968
biomass	Resource	kg	4.33	4.33	0.000387	0.000387	33.5	33.5
borax	Resource	kg	0.00016	0.00016	x	x	0.00198	0.00198
boron (in ore)	Resource	kg	0	0	0	0	x	x
calcium sulphate	Resource	kg	0.000306	0.000306	0.000112	0.000112	0.0018	0.00138
chalk	Resource	kg	1.02E-23	1.02E-23	1.02E-23	1.02E-23	2.84E-12	2.84E-12
chromium (in ore)	Resource	kg	0.000114	0.000114	0.0000519	0.0000519	0.00226	0.00226
chromium (ore)	Resource	kg	0.000000889	0.000000889	8.71E-08	8.71E-08	0.000000028	0.000000015
clay	Resource	kg	4.21	4.21	2.93	2.93	50.3	36.9
clay minerals	Resource	kg	0.00002	0.00002	0.00000358	0.00000358	0.0145	0.0145
coal	Resource	kg	11.6	11.6	2.68	2.68	7.57	10.5
coal ETH	Resource	kg	136	136	102	102	35.1	35.1
coal FAL	Resource	kg	18.1	18.1	1.59	1.59	x	x
cobalt (in ore)	Resource	kg	2.05E-10	2.05E-10	1.28E-10	1.28E-10	7.78E-09	7.78E-09
coconuts	Resource	kg	0.0108	0.0108	0.0108	0.0108	x	x
copper (in ore)	Resource	kg	0.000847	0.000847	0.000218	0.000218	0.00337	0.00337
copper (ore)	Resource	kg	0.000021	0.000021	0.0000149	0.0000149	0.000251	0.000183
corn seedlings	Resource	kg	0.00213	0.00213	0.000203	0.000203	x	x
crude oil	Resource	kg	11.8	11.8	3.81	3.81	79.5	79.2
crude oil (feedstock)	Resource	kg	0.0359	0.0359	x	x	-0.585	-0.585
crude oil ETH	Resource	kg	5.63	5.63	24.1	24.1	11.2	11.2
crude oil FAL	Resource	kg	2.47	2.47	1.31	1.31	x	x
crude oil IDEMAT	Resource	kg	7.62	7.62	25.5	25.5	17.6	17.6
dolomite	Resource	kg	0.0000555	0.0000555	0.0000378	0.0000378	0.000963	0.00114
energy (undef.)	Resource	MJ	41.5	41.5	21.8	21.8	159	159
energy from biomass	Resource	MJ	x	x	x	x	1220	1220
energy from coal	Resource	MJ	x	x	x	x	0.00137	0.00137
energy from hydro power	Resource	MJ	25.7	25.7	1.95	1.95	0.34	0.34
energy from uranium	Resource	MJ	0.00000751	0.00000751	0.00000503	0.00000503	7.61	7.61
feldspar	Resource	kg	8.58E-30	8.58E-30	8.58E-30	8.58E-30	0.00711	0.00711
ferromanganese	Resource	kg	0.00000535	0.00000535	0.00000535	0.00000535	0.0000994	0.0000994
fluorspar	Resource	kg	0.000229	0.000229	0.000236	0.000236	0.00127	0.00127
gas from oil production	Resource	m3	0.0000699	0.0000699	0.0000735	0.0000735	0.000705	0.000705
glue	Resource	kg	0.000557	0.000557	x	x	0.00689	0.00689
granite	Resource	kg	0.0000621	0.0000621	0.0000621	0.0000621	0.00066	0.00066
gravel	Resource	kg	0.356	0.356	0.251	0.251	17.4	17.3
herbicide	Resource	kg	0.00000608	0.00000608	x	x	0.0000752	0.0000752
ilmenite	Resource	kg	0.0000089	0.0000089	0.00000776	0.00000776	0.000135	0.0000983
ink	Resource	kg	x	x	x	x	0.00000148	0.00000148
iron (in ore)	Resource	kg	0.0707	0.0707	0.0343	0.0343	0.608	0.608
iron (ore)	Resource	kg	-0.000651	-0.000651	0.00248	0.00248	-0.0321	-0.0217
K	Resource	kg	0.00000212	0.00000212	0.000000203	0.000000203	x	x
K-fertiliser	Resource	kg	0.291	0.291	0.195	0.195	x	x
KCl	Resource	kg	0.555	0.555	0.053	0.053	0.585	0.585
lead (in ore)	Resource	kg	0.000185	0.000185	0.000117	0.000117	0.00891	0.00891

lead (ore)	Resource	kg	-0.00117	-0.00117	-0.000112	-0.000112	0.00000454	0.00000452
lignite	Resource	kg	1.89	1.89	0.594	0.594	13.7	13.7
lignite ETH	Resource	kg	2.67	2.67	4.71	4.71	2.41	2.41
limestone	Resource	kg	10.5	10.5	3.6	3.6	11.4	11.2
lubricant	Resource	kg	x	x	x	x	0.0000374	0.0000374
lubricating oil	Resource	kg	x	x	x	x	0.00374	0.00374
magnesium (ore)	Resource	kg	0	0	0	0	x	x
maize, corn (t86)	Resource	kg	0.035	0.035	x	x	0.433	0.433
manganese (in ore)	Resource	kg	0.0000291	0.0000291	0.0000137	0.0000137	0.000674	0.000674
manganese (ore)	Resource	kg	0.000000506	0.000000506	0.0000243	0.0000243	1.63E-08	8.79E-09
manure	Resource	kg	0.0456	0.0456	x	x	0.559	0.559
marl	Resource	kg	6.68	6.68	2.66	2.66	0.578	0.578
methane (kg)	Resource	kg	0.000132	0.000132	0.000138	0.000138	0.000419	0.000419
methane (kg) ETH	Resource	kg	0.0381	0.0381	0.0143	0.0143	0.00738	0.00738
molybdene (in ore)	Resource	kg	8.88E-10	8.88E-10	2.28E-10	2.28E-10	2.92E-09	2.92E-09
Na2SO4	Resource	kg	x	x	x	x	0.000171	0.000171
NaCl	Resource	kg	16	16	1.69	1.69	21.2	21.2
NaOH	Resource	kg	x	x	x	x	0.0428	0.0428
natural gas	Resource	kg	11.7	11.7	5.31	5.31	77.8	77.7
natural gas (feedstock)	Resource	m3	0.0393	0.0393	x	x	-0.714	-0.714
natural gas (vol)	Resource	m3	0.592	0.592	0.182	0.182	1.05	1.05
natural gas ETH	Resource	m3	47.6	47.6	162	162	11.8	11.8
natural gas FAL	Resource	kg	5.27	5.27	2.4	2.4	x	x
nickel (in ore)	Resource	kg	0.0000646	0.0000646	0.0000243	0.0000243	0.00124	0.00124
nickel (ore)	Resource	kg	0.000000294	0.000000294	2.89E-08	2.89E-08	9.48E-09	5.1E-09
nitrogen	Resource	kg	0.155	0.155	0.155	0.155	4.49	4.49
olivine	Resource	kg	0.0000656	0.0000656	0.0000562	0.0000562	0.00111	0.00111
oxygen	Resource	kg	0.0243	0.0243	0.0243	0.0243	0.509	0.509
P2O5	Resource	kg	0.0146	0.0146	0.00000136	0.00000136	0.00121	0.00121
palladium (in ore)	Resource	kg	1.06E-09	1.06E-09	6.92E-10	6.92E-10	4.81E-09	4.81E-09
peroxitan	Resource	kg	0.00104	0.00104	x	x	0.0128	0.0128
pesticides	Resource	kg	0.0000367	0.0000367	x	x	0.00271	0.00271
petroleum gas ETH	Resource	m3	0.0639	0.0639	0.0172	0.0172	0.272	0.272
phosphate (ore)	Resource	kg	0.214	0.214	0.182	0.182	3.24	2.38
platinum (in ore)	Resource	kg	1.19E-09	1.19E-09	7.84E-10	7.84E-10	5.81E-09	5.81E-09
pot. energy hydropower	Resource	MJ	44.8	44.8	295	295	16.1	16.1
potatoes (t100)	Resource	kg	0.0369	0.0369	0.00262	0.00262	0.115	0.115
potential energy water ETH	Resource	MJ	4.65	4.65	1.03	1.03	2.98	2.98
pressed wire	Resource	kg	0.000314	0.000314	x	x	0.00561	0.00561
process and cooling water	Resource	m3	0.00157	0.00157	0.00552	0.00552	-0.0207	-0.0207
pyrites ash	Resource	kg	0.00724	0.00724	0.000717	0.000717	0.000367	0.000223
quartz sand	Resource	kg	0.0134	0.0134	0.00128	0.00128	0.0254	0.0254
reservoir content ETH	Resource	m3y	0.101	0.101	0.0224	0.0224	0.064	0.064
resin glue	Resource	kg	x	x	x	x	-0.000287	-0.000287
retention agents	Resource	kg	0.000414	0.000414	x	x	0.00512	0.00512
rhenium (in ore)	Resource	kg	1.12E-09	1.12E-09	5.91E-10	5.91E-10	4.12E-09	4.12E-09
rhodium (in ore)	Resource	kg	1.12E-09	1.12E-09	7.38E-10	7.38E-10	5.19E-09	5.19E-09
rock salt	Resource	kg	9.14	9.14	5	5	0.358	0.358
rutile	Resource	kg	1.46E-23	1.46E-23	1.46E-23	1.46E-23	0.00000142	0.00000142
S-containing raw material	Resource	kg	0.00051	0.00051	x	x	0	0
salt	Resource	kg	0.0628	0.0628	0.0417	0.0417	x	x
sand	Resource	kg	6.03	6.03	5.32	5.32	63.6	46.8
sand, clay	Resource	kg	0.00000131	0.00000131	0.000273	0.000273	-0.000023	-0.000023
shale	Resource	kg	0.0000172	0.0000172	0.0000172	0.0000172	0.0012	0.0012
silicon	Resource	kg	x	x	x	x	0.0106	0.0106
silicon (in SiO2)	Resource	kg	0.000000003	0.000000003	2.61E-09	2.61E-09	4.54E-08	3.31E-08
silver	Resource	kg	2.62E-08	2.62E-08	6.64E-09	6.64E-09	4.35E-08	4.32E-08
silver (in ore)	Resource	kg	0.00000292	0.00000292	0.000000783	0.000000783	0.0000119	0.0000119
slate	Resource	kg	x	x	x	x	0.00000225	0.00000225
SO2 secondary	Resource	kg	0.0401	0.0401	0.00352	0.00352	0.00189	0.00189
sodium dichromate	Resource	kg	x	x	x	x	0	0

soil	Resource	kg	x	x	x	x	0.00000524	0.00000524
steel scrap	Resource	kg	0.00238	0.00238	0.00163	0.00163	0.0261	0.0186
sulphur	Resource	kg	0.46	0.46	0.193	0.193	1.08	0.993
Swiss base brown	Resource	kg	0.000228	0.000228	x	x	0.00282	0.00282
tin (in ore)	Resource	kg	0.00000163	0.00000163	0.000000438	0.000000438	0.00000659	0.00000659
turbine water ETH	Resource	m3	24.5	24.5	5.4	5.4	15.6	15.6
unspecified energy	Resource	MJ	x	x	x	x	-51.2	-51.2
uranium (in ore)	Resource	kg	0.00359	0.00359	0.00434	0.00434	0.00105	0.00105
uranium (in ore) ETH	Resource	kg	0.0000712	0.0000712	0.0000156	0.0000156	0.0000391	0.0000391
uranium (ore)	Resource	kg	0.000416	0.000416	0.000398	0.000398	-0.00057	-0.000572
uranium FAL	Resource	kg	0.000071	0.000071	0.00000563	0.00000563	x	x
urea, carbamide	Resource	kg	0.00148	0.00148	x	x	0.0184	0.0184
waste paper (feedstock)	Resource	kg	2.23	2.23	0.163	0.163	6.48	6.48
water	Resource	kg	85000	85000	63000	63000	2170	2170
water (drinking, for process.)	Resource	kg	x	x	x	x	0	0
water (process)	Resource	kg	323	323	44.7	44.7	12000	12000
water (sea, for processing)	Resource	kg	0.0693	0.0693	0.00662	0.00662	0.0000687	0.0000511
water (surface, for cooling)	Resource	kg	648	648	648	648	20200	20200
water (surface, for process.)	Resource	kg	0.000322	0.000322	0.0000308	0.0000308	x	x
water (well, for cooling)	Resource	kg	-0.00256	-0.00256	-0.00243	-0.00243	-0.0356	-0.0235
water (well, for processing)	Resource	kg	0.000453	0.000453	166	166	0.000000237	0.000000186
wood	Resource	kg	2.26	2.26	1.09	1.09	-3.23	-3.22
wood (dry matter) ETH	Resource	kg	0.0416	0.0416	0.0149	0.0149	0.0348	0.0348
wood (feedstock)	Resource	kg	0.458	0.458	x	x	-2.51	-2.51
wood (volume)	Resource	m3	0.0000222	0.0000222	0.00000212	0.00000212	x	x
wood for fiber (feedstock) FAL	Resource	kg	7.95	7.95	7.95	7.95	x	x
wood/wood wastes FAL	Resource	kg	4.96	4.96	4.95	4.95	x	x
zeolite	Resource	kg	8.04E-08	8.04E-08	8.46E-08	8.46E-08	0.000000975	0.000000975
zinc (in ore)	Resource	kg	0.00000416	0.00000416	0.00000302	0.00000302	0.000249	0.000249
zinc (ore)	Resource	kg	0.000000829	0.000000829	0.000000698	0.000000698	0.0000121	0.0000088
1,1,1-trichloroethane	Air	kg	0.0000177	0.0000177	0.0000152	0.0000152	0.000263	0.000192
1,2-dichloroethane	Air	kg	1.99E-10	1.99E-10	2.09E-10	2.09E-10	5.18E-09	5.18E-09
acetaldehyde	Air	kg	0.000259	0.000259	0.000218	0.000218	0.00362	0.00265
acetic acid	Air	kg	0.0000489	0.0000489	0.00000715	0.00000715	0.00000738	0.0000068
acetone	Air	kg	0.00000789	0.00000789	0.00000128	0.00000128	0.00000163	0.00000153
acids	Air	kg	0.000000582	0.000000582	5.55E-08	5.55E-08	x	x
acrolein	Air	kg	0.000000612	0.000000612	4.77E-08	4.77E-08	4.69E-09	4.69E-09
Al	Air	kg	0.000705	0.000705	-0.0000261	-0.0000261	-0.00305	-0.00253
alcohols	Air	kg	0.000436	0.000436	0.000374	0.000374	0.00648	0.00474
aldehydes	Air	kg	0.000458	0.000458	0.000473	0.000473	0.000193	0.000193
alkanes	Air	kg	0.00086	0.00086	0.000298	0.000298	0.00415	0.00304
alkenes	Air	kg	0.0000633	0.0000633	0.00000165	0.00000165	-0.000154	-0.000127
ammonia	Air	kg	0.0267	0.0267	0.00437	0.00437	0.00302	0.0029
As	Air	kg	0.00000477	0.00000477	0.000000703	0.000000703	-0.00000262	-0.00000164
B	Air	kg	0.000128	0.000128	0.00000748	0.00000748	-0.000269	-0.00022
Ba	Air	kg	0.0000203	0.0000203	0.0000106	0.0000106	-0.0000364	-0.0000303
Be	Air	kg	0.000000436	0.000000436	3.89E-08	3.89E-08	-0.000000539	-0.000000438
benzaldehyde	Air	kg	4.13E-11	4.13E-11	2.52E-11	2.52E-11	1.61E-09	1.61E-09
benzene	Air	kg	0.0012	0.0012	0.00557	0.00557	0.00175	0.00166
benzo(a)pyrene	Air	kg	0.000000297	0.000000297	2.01E-08	2.01E-08	-0.000000413	-0.000000331
Br	Air	kg	0.0000155	0.0000155	7.32E-08	7.32E-08	-0.0000558	-0.0000461
butane	Air	kg	0.000671	0.000671	0.000237	0.000237	0.00325	0.00246
butene	Air	kg	0.00000756	0.00000756	0.00000347	0.00000347	0.000149	0.000148

Ca	Air	kg	0.000319	0.000319	0.0000271	0.0000271	-0.000315	-0.000253
Cd	Air	kg	0.00000514	0.00000514	0.00000638	0.00000638	0.0000115	0.0000114
CFC-11	Air	kg	0.00000014	0.00000014	1.62E-08	1.62E-08	1.24E-08	1.24E-08
CFC-114	Air	kg	0.000000595	0.000000595	0.000000131	0.000000131	0.000000327	0.000000327
CFC-116	Air	kg	2.67E-08	2.67E-08	1.02E-08	1.02E-08	0.000000527	0.000000527
CFC-12	Air	kg	0.0000151	0.0000151	0.000013	0.000013	0.000225	0.000165
CFC-13	Air	kg	3.04E-09	3.04E-09	6.69E-10	6.69E-10	1.67E-09	1.67E-09
CFC-14	Air	kg	0.000000252	0.000000252	0.000000102	0.000000102	0.00000491	0.00000486
CFC (hard)	Air	kg	2.08E-09	2.08E-09	1.99E-10	1.99E-10	x	x
chlorobenzene	Air	kg	x	x	x	x	1.14E-15	1.14E-15
chlorophenols	Air	kg	x	x	x	x	2.28E-15	2.28E-15
Cl2	Air	kg	0.0000906	0.0000906	0.0000512	0.0000512	0.0000216	0.0000216
CO	Air	kg	0.96	0.96	0.567	0.567	1.52	1.51
CO2	Air	kg	380	380	673	673	176	176
CO2 (fossil)	Air	kg	127	127	31.8	31.8	314	318
CO2 (non-fossil)	Air	kg	23	23	13.7	13.7	260	223
coal dust	Air	kg	0.00000109	0.00000109	0.000000728	0.000000728	x	x
cobalt	Air	kg	0.00000356	0.00000356	0.000000504	0.000000504	0.00000138	0.00000151
Cr	Air	kg	0.00000691	0.00000691	0.00000388	0.00000388	0.0000599	0.000061
Cr (III)	Air	kg	9.81E-14	9.81E-14	9.36E-15	9.36E-15	x	x
CS2	Air	kg	0.00000507	0.00000507	0.000000485	0.000000485	0.00000906	0.00000906
Cu	Air	kg	0.0000053	0.0000053	0.000000862	0.000000862	0.00002	0.0000207
CxHy	Air	kg	0.207	0.207	0.124	0.124	0.215	0.21
CxHy aromatic	Air	kg	0.109	0.109	0.0144	0.0144	0.00851	0.0067
CxHy chloro	Air	kg	0.000000119	0.000000119	0.000000138	0.000000138	0.0000108	0.0000108
CxHy halogenated	Air	kg	0.0000828	0.0000828	0.00000791	0.00000791	2.74E-09	2.26E-09
CxHy;kg	Air	kg	7.36E-09	7.36E-09	7.02E-10	7.02E-10	x	x
cyanides	Air	kg	0.000000346	0.000000346	2.24E-08	2.24E-08	-0.000000669	-0.000000535
dichloroethane	Air	kg	0.0000612	0.0000612	0.0000524	0.0000524	0.000917	0.000674
dichloromethane	Air	kg	0.00000264	0.00000264	0.00000189	0.00000189	7.67E-09	7.67E-09
dioxin (TEQ)	Air	kg	1.57E-11	1.57E-11	9.42E-12	9.42E-12	1.73E-10	1.32E-10
dust	Air	kg	0.363	0.363	0.306	0.306	0.121	0.121
dust (coarse)	Air	kg	0.0000667	0.0000667	0.0000702	0.0000702	-0.0282	-0.0282
dust (coarse) process	Air	kg	0.00541	0.00541	0.00207	0.00207	0.0051	0.0051
dust (PM10) mobile	Air	kg	0.000106	0.000106	0.0000631	0.0000631	0.00477	0.00477
dust (PM10) stationary	Air	kg	0.00335	0.00335	0.00104	0.00104	0.00264	0.00264
dust (SPM)	Air	kg	0.00827	0.00827	0.0199	0.0199	0.0202	0.0202
ethane	Air	kg	0.00324	0.00324	0.000576	0.000576	0.00289	0.00208
ethanol	Air	kg	0.0000158	0.0000158	0.00000257	0.00000257	0.00000325	0.00000304
ethene	Air	kg	0.00247	0.00247	0.000711	0.000711	0.0116	0.00957
ethylbenzene	Air	kg	0.0000103	0.0000103	0.00178	0.00178	0.0000108	0.0000105
ethylene glycol	Air	kg	0.00000756	0.00000756	0.00000756	0.00000756	x	x
ethylene oxide	Air	kg	0.00000135	0.00000135	0.00000135	0.00000135	x	x
ethyne	Air	kg	-0.00000721	-0.00000721	-0.00000587	-0.00000587	-0.00016	-0.000134
F2	Air	kg	0.0000126	0.0000126	0.0000546	0.0000546	0.00000974	0.00000974
Fe	Air	kg	0.000348	0.000348	0.00000913	0.00000913	-0.00118	-0.000976
fluoride	Air	kg	0.0000379	0.0000379	0.00000836	0.00000836	0.00000115	0.000000846
formaldehyde	Air	kg	0.0014	0.0014	0.00359	0.00359	0.000461	0.000464
glycerol	Air	kg	0.0000644	0.0000644	0.00000615	0.00000615	x	x
H2	Air	kg	0.0415	0.0415	0.00529	0.00529	0.0369	0.0365
H2S	Air	kg	0.000278	0.000278	0.000062	0.000062	0.000954	0.000976
H2SO4	Air	kg	0.0000051	0.0000051	0.000000487	0.000000487	0.00000906	0.00000906
HALON-1301	Air	kg	0.00000224	0.00000224	0.00000592	0.00000592	0.00000339	0.00000336
HCFC-21	Air	kg	0.000000606	0.000000606	0.00000312	0.00000312	0.0000394	0.0000394
HCFC-22	Air	kg	0.0000138	0.0000138	0.0000116	0.0000116	0.000201	0.000147
HCl	Air	kg	0.0696	0.0696	0.0473	0.0473	0.0313	0.0326
HCN	Air	kg	0.00000507	0.00000507	0.000000485	0.000000485	0.0000133	0.0000133
He	Air	kg	0.0000643	0.0000643	0.0000173	0.0000173	0.000275	0.000275
heptane	Air	kg	0.0000557	0.0000557	0.00000887	0.00000887	0.0000798	0.0000766
hexachlorobenzene	Air	kg	3.94E-12	3.94E-12	1.06E-12	1.06E-12	2.53E-11	2.53E-11
hexane	Air	kg	0.000105	0.000105	0.0000174	0.0000174	0.000172	0.000166
HF	Air	kg	0.0184	0.0184	0.00496	0.00496	0.00252	0.00255
HFC-134a	Air	kg	x	x	-2.87E-20	-2.87E-20	x	x
Hg	Air	kg	0.0000202	0.0000202	0.0000183	0.0000183	0.0000572	0.0000564

I	Air	kg	0.00000481	0.00000481	0.000000213	0.000000213	-0.0000135	-0.0000111
isopropanol	Air	kg	0.0000505	0.0000505	0.00000482	0.00000482	x	x
K	Air	kg	0.00201	0.00201	0.00192	0.00192	-0.000283	-0.000222
kerosene	Air	kg	0.0000156	0.0000156	0.00000121	0.00000121	x	x
ketones	Air	kg	0.0000523	0.0000523	0.0000448	0.0000448	0.000777	0.000568
La	Air	kg	0.000000257	0.000000257	-3.25E-09	-3.25E-09	-0.000000956	-0.000000794
mercaptans	Air	kg	0.0000991	0.0000991	0.0000817	0.0000817	0.00137	0.00101
metals	Air	kg	0.0165	0.0165	0.0141	0.0141	0.00552	0.00552
methane	Air	kg	2.2	2.2	2.45	2.44	6.09	4.78
methanol	Air	kg	0.0000463	0.0000463	0.00000598	0.00000598	0.00000511	0.0000045
methyl chloride	Air	kg	0.0000673	0.0000673	0.00000642	0.00000642	x	x
Mg	Air	kg	0.000259	0.000259	-0.00000789	-0.00000789	-0.00107	-0.000887
Mn	Air	kg	0.0000575	0.0000575	0.0000539	0.0000539	0.0000921	0.0000931
Mo	Air	kg	0.0000014	0.0000014	0.00000015	0.00000015	-0.000000895	-0.00000071
MTBE	Air	kg	1.14E-08	1.14E-08	8.51E-09	8.51E-09	0.000000761	0.000000761
n-nitrodimethylamine	Air	kg	0.000000129	0.000000129	1.01E-08	1.01E-08	x	x
N2	Air	kg	0.000121	0.000121	0.000159	0.000159	0.0000367	0.0000367
N2O	Air	kg	0.02	0.02	0.0161	0.0161	0.0201	0.0197
Na	Air	kg	0.00014	0.00014	0.0000504	0.0000504	-0.000169	-0.000139
naphthalene	Air	kg	0.00000594	0.00000594	0.000302	0.000302	x	x
Ni	Air	kg	0.000276	0.000276	0.000535	0.000535	0.000107	0.000108
NO2	Air	kg	0.00161	0.00161	0.0126	0.0126	x	x
non methane VOC	Air	kg	0.176	0.176	0.348	0.348	0.188	0.188
NOx	Air	kg	0.488	0.488	0.472	0.472	0.368	0.368
NOx (as NO2)	Air	kg	1.12	1.12	1.14	1.14	2.28	2.27
odorous sulfur	Air	kg	0.0000275	0.0000275	0.0000275	0.0000275	x	x
organic substances	Air	kg	0.0103	0.0103	0.0108	0.0108	0.0214	0.0214
P	Air	kg	0.00000561	0.00000561	-0.000000429	-0.000000429	-0.0000272	-0.0000227
P-tot	Air	kg	0.00000103	0.00000103	0.000000279	0.000000279	0.000000659	0.000000659
P2O5	Air	kg	6.63E-09	6.63E-09	-3.03E-11	-3.03E-11	-1.85E-08	-1.54E-08
PAH's	Air	kg	0.0000287	0.0000287	0.0000611	0.0000611	0.0000213	0.0000213
particulates (PM10)	Air	kg	0.0171	0.0171	0.00655	0.00655	0.00073	0.00073
particulates (SPM)	Air	kg	x	x	x	x	0.00426	0.00426
particulates (unspecified)	Air	kg	0.178	0.178	0.0562	0.0562	0.623	0.6
Pb	Air	kg	0.0000678	0.0000678	0.0000828	0.0000828	0.000058	0.0000619
pentachlorobenzene	Air	kg	1.05E-11	1.05E-11	2.84E-12	2.84E-12	6.79E-11	6.79E-11
pentachlorophenol	Air	kg	1.69E-12	1.69E-12	4.59E-13	4.59E-13	1.1E-11	1.1E-11
pentane	Air	kg	0.000431	0.000431	0.00599	0.00599	0.000432	0.000414
phenol	Air	kg	0.000102	0.000102	0.0000988	0.0000988	0.000000181	0.000000134
phosphate	Air	kg	0.00000395	0.00000395	0.00000265	0.00000265	x	x
propane	Air	kg	0.00102	0.00102	0.000213	0.000213	0.0016	0.00121
propanoic acid	Air	kg	9.52E-12	9.52E-12	1.08E-11	1.08E-11	1.07E-10	4.76E-11
propene	Air	kg	0.000073	0.000073	0.00000523	0.00000523	-0.000138	-0.00011
propionaldehyde	Air	kg	3.66E-12	3.66E-12	3.59E-13	3.59E-13	1.18E-13	6.37E-14
propionic acid	Air	kg	0.000000185	0.000000185	6.24E-08	6.24E-08	9.54E-08	9.54E-08
Pt	Air	kg	6.45E-10	6.45E-10	4.89E-10	4.89E-10	0.000000045	0.000000045
Sb	Air	kg	0.000000777	0.000000777	8.28E-08	8.28E-08	0.00000713	0.00000723
Sc	Air	kg	8.22E-08	8.22E-08	-1.52E-09	-1.52E-09	-0.000000324	-0.000000269
Se	Air	kg	0.00000685	0.00000685	0.000000565	0.000000565	-0.00000284	-0.00000187
Si	Air	kg	0.0000437	0.0000437	0.00000244	0.00000244	x	x
silicates	Air	kg	0.000136	0.000136	0.000017	0.000017	-0.000918	-0.000744
Sn	Air	kg	7.25E-08	7.25E-08	3.43E-09	3.43E-09	0.000000675	0.000000708
SO2	Air	kg	0.0886	0.0886	0.122	0.122	1.67	1.67
soot	Air	kg	0.00154	0.00154	0.0368	0.0368	0.00244	0.00244
SOx	Air	kg	0.486	0.486	0.199	0.199	0.151	0.151
SOx (as SO2)	Air	kg	1.33	1.33	1.54	1.54	0.219	0.236
Sr	Air	kg	0.0000138	0.0000138	-0.000000552	-0.000000552	-0.0000598	-0.0000498
tar	Air	kg	0.000000138	0.000000138	1.32E-08	1.32E-08	3.35E-10	2.41E-10
tetrachloroethene	Air	kg	0.0000328	0.0000328	0.0000277	0.0000277	0.000479	0.00035
tetrachloromethane	Air	kg	0.000000982	0.000000982	0.000000364	0.000000364	1.79E-08	1.79E-08

Th	Air	kg	0.000000154	0.000000154	-2.82E-09	-2.82E-09	-0.000000609	-0.000000506
Ti	Air	kg	0.0000246	0.0000246	-0.000000845	-0.000000845	-0.000107	-0.0000885
Tl	Air	kg	6.45E-08	6.45E-08	-2.93E-09	-2.93E-09	7.62E-08	0.000000126
toluene	Air	kg	0.0000785	0.0000785	0.00772	0.00772	0.0000091	0.0000142
total reduced sulfur	Air	kg	0.00055	0.00055	0.00055	0.00055	2.81E-08	2.81E-08
trichloroethene	Air	kg	0.000000578	0.000000578	0.000000045	0.000000045	x	x
trichloromethane	Air	kg	2.21E-09	2.21E-09	5.74E-10	5.74E-10	1.86E-09	1.86E-09
U	Air	kg	0.000000148	0.000000148	-3.21E-09	-3.21E-09	-0.000000406	-0.000000305
unspecified emission	Air	kg	0.000107	0.000107	0.0000102	0.0000102	-0.00000522	-0.00000522
V	Air	kg	0.000159	0.000159	0.0000222	0.0000222	0.0000308	0.0000304
vinyl chloride	Air	kg	6.85E-08	6.85E-08	5.84E-08	5.84E-08	0.00001	0.00001
VOC	Air	kg	0.122	0.122	0.0752	0.0752	0.585	0.585
water	Air	kg	1.71	1.71	2.91	2.91	25.4	18.6
xylene	Air	kg	0.0000549	0.0000549	0.0000096	0.0000096	0.000144	0.000148
Zn	Air	kg	0.000121	0.000121	0.00121	0.00121	0.000456	0.000458
Zr	Air	kg	0.00000019	0.00000019	8.51E-09	8.51E-09	-0.000000456	-0.000000379
1,1,1-trichloroethane	Water	kg	1.44E-10	1.44E-10	0.000000207	0.000000207	1.01E-08	1.01E-08
acenaphthylene	Water	kg	0.000000397	0.000000397	0.000000225	0.000000225	0.000000206	0.000000206
acetic acid	Water	kg	0.0453	0.0453	0.00433	0.00433	x	x
Acid as H+	Water	kg	0.0199	0.0199	0.00387	0.00387	0.00673	0.00497
acids (unspecified)	Water	kg	0.000716	0.000716	0.00071	0.00071	0.0125	0.0125
Ag	Water	kg	0.000000159	0.000000159	2.36E-08	2.36E-08	0.000000193	0.000000182
Al	Water	kg	0.229	0.229	0.165	0.165	0.0589	0.0589
alkanes	Water	kg	0.0000346	0.0000346	0.00000491	0.00000491	0.0000345	0.0000322
alkenes	Water	kg	0.0000032	0.0000032	0.000000453	0.000000453	0.00000318	0.00000297
anorg. dissolved subst.	Water	kg	0.813	0.813	1.06	1.06	0.365	0.365
AOX	Water	kg	0.000205	0.000205	0.0000234	0.0000234	0.00624	0.00624
As	Water	kg	0.000443	0.000443	0.000331	0.000331	0.000135	0.000131
B	Water	kg	0.00169	0.00169	0.00016	0.00016	0.00000882	0.00000853
Ba	Water	kg	0.0189	0.0189	0.0161	0.0161	0.00605	0.006
baryte	Water	kg	0.00177	0.00177	0.000497	0.000497	0.00354	0.00352
Be	Water	kg	3.82E-09	3.82E-09	1.08E-09	1.08E-09	9.05E-09	9.05E-09
benzene	Water	kg	0.0000347	0.0000347	0.0000051	0.0000051	0.0000357	0.0000333
benzo(a)pyrene	Water	kg	x	x	x	x	1.76E-13	1.76E-13
BOD	Water	kg	2.05	2.05	0.819	0.816	1.02	0.797
Br	Water	kg	x	x	x	x	0.00000477	0.00000477
calcium compounds	Water	kg	0.0000297	0.0000297	0.0000311	0.0000311	0.00995	0.00995
calcium ions	Water	kg	3.34	3.34	1.36	1.36	1.09	0.765
carbonate	Water	kg	0.938	0.938	0.0896	0.0896	0.0194	0.0194
Cd	Water	kg	0.0000392	0.0000392	0.0000285	0.0000285	0.000205	0.000151
chlorate ion (ClO3-)	Water	kg	0.000204	0.000204	0.0000194	0.0000194	0.0074	0.0074
chlorinated solvents (unspec.)	Water	kg	0.000000682	0.000000682	0.000000594	0.000000594	0.0000103	0.00000754
chlorobenzenes	Water	kg	5.72E-13	5.72E-13	3.74E-12	3.74E-12	4.03E-11	4.03E-11
chromate	Water	kg	0.00000556	0.00000556	0.000000594	0.000000594	0.00000906	0.00000906
Cl-	Water	kg	15.6	15.6	6.73	6.73	4.35	3.86
Cl2	Water	kg	0.00014	0.00014	0.0000137	0.0000137	0.0000982	0.0000963
Co	Water	kg	0.0000145	0.0000145	0.00000537	0.00000537	0.00000334	0.00000334
COD	Water	kg	6.09	6.08	4.14	4.13	1.4	1.4
Cr	Water	kg	0.00221	0.00221	0.00176	0.00176	0.000602	0.000599
Cr (III)	Water	kg	0.0000456	0.0000456	0.00000915	0.00000915	0.00015	0.000107
Cr (VI)	Water	kg	8.67E-09	8.67E-09	2.96E-09	2.96E-09	3.75E-09	3.35E-09
crude oil	Water	kg	0.000205	0.000205	0.000049	0.000049	0.00115	0.00115
Cs	Water	kg	0.000000114	0.000000114	2.01E-08	2.01E-08	0.000000217	0.000000212
Cu	Water	kg	0.00117	0.00117	0.000879	0.000878	0.00121	0.000933
CxHy	Water	kg	0.271	0.271	0.0267	0.0267	0.005	0.00498
CxHy aromatic	Water	kg	0.000481	0.000481	0.00133	0.00133	0.000442	0.000442
CxHy chloro	Water	kg	0.0000009	0.0000009	0.00000345	0.00000345	0.000151	0.000151
cyanide	Water	kg	0.0000292	0.0000292	0.000103	0.000103	0.00000527	0.00000908
detergent/oil	Water	kg	3.03	3.03	0.289	0.289	0.00843	0.00843

di(2-ethylhexyl)phthalate	Water	kg	4.89E-12	4.89E-12	1.57E-09	1.57E-09	8.04E-11	8.04E-11
diamines	Water	kg	-5.28E-12	-5.28E-12	-1.08E-12	-1.08E-12	-1.4E-10	-1.47E-10
dibutyl p-phthalate	Water	kg	4.01E-11	4.01E-11	2.27E-11	2.27E-11	2.09E-11	2.09E-11
dichloroethane	Water	kg	4.37E-08	4.37E-08	1.18E-08	1.18E-08	0.0000091	0.0000091
dichloromethane	Water	kg	0.000000433	0.000000433	0.000000184	0.000000184	0.0000016	0.0000016
dimethyl p-phthalate	Water	kg	2.52E-10	2.52E-10	1.43E-10	1.43E-10	1.32E-10	1.32E-10
dioxins (TEQ)	Water	kg	1.44E-10	1.44E-10	1.3E-10	1.3E-10	2.13E-09	1.5E-09
dissolved organics	Water	kg	0.000224	0.000224	0.000788	0.000788	0.0369	0.0369
dissolved solids	Water	kg	0.291	0.291	0.137	0.137	0.37	0.37
dissolved substances	Water	kg	0.217	0.217	0.0211	0.0211	-0.014	-0.0122
DOC	Water	kg	0.0143	0.0143	0.00364	0.00364	0.000158	0.000157
EDTA	Water	kg	7.93E-09	7.93E-09	7.57E-10	7.57E-10	x	x
ethanol	Water	kg	0.0171	0.0171	0.00164	0.00164	-8.81E-09	-9.26E-09
ethyl benzene	Water	kg	0.00000627	0.00000627	0.00000108	0.00000108	0.00000638	0.00000595
ethylenediamine	Water	kg	-1.14E-11	-1.14E-11	-2.32E-12	-2.32E-12	-3.03E-10	-3.18E-10
F2	Water	kg	x	x	x	x	-0.000000432	-0.000000432
fats/oils	Water	kg	0.000979	0.000979	0.000408	0.000408	0.0043	0.00421
fatty acids as C	Water	kg	0.11	0.11	0.0375	0.0375	0.541	0.399
Fe	Water	kg	0.0769	0.0769	0.0588	0.0588	0.0437	0.0387
fluoride ions	Water	kg	0.0222	0.0222	0.016	0.016	0.000111	0.000117
formaldehyde	Water	kg	4.49E-10	4.49E-10	2.27E-10	2.27E-10	1.33E-08	1.33E-08
glutaraldehyde	Water	kg	0.000000117	0.000000117	5.13E-08	5.13E-08	0.000000433	0.000000433
H2	Water	kg	0.0000709	0.0000709	0.000595	0.000595	0.000355	0.000355
H2S	Water	kg	0.00000117	0.00000117	0.000000472	0.000000472	0.00000062	0.00000062
H2SO4	Water	kg	0.000419	0.000419	0.0017	0.0017	x	x
HCl	Water	kg	x	x	0.00125	0.00125	x	x
herbicides	Water	kg	x	x	3.2E-11	3.2E-11	x	x
hexachloroethane	Water	kg	9.58E-13	9.58E-13	2.48E-13	2.48E-13	8.07E-13	8.07E-13
Hg	Water	kg	0.00000613	0.00000613	0.0015	0.0015	0.0000144	0.0000131
HNO3	Water	kg	x	x	x	x	0.000000591	0.000000591
HOCL	Water	kg	0.0000117	0.0000117	0.00000267	0.00000267	0.00000727	0.00000727
I	Water	kg	0.0000261	0.0000261	0.00000365	0.00000365	0.0000265	0.0000247
inorganic general	Water	kg	0.122	0.122	0.0116	0.0116	0.000357	0.000353
isopropanol	Water	kg	0.000000139	0.000000139	1.33E-08	1.33E-08	x	x
K	Water	kg	0.0653	0.0653	0.041	0.041	0.67	0.498
Kjeldahl-N	Water	kg	0.0000578	0.0000578	0.00013	0.00013	0.000109	0.000109
metallic ions	Water	kg	0.0239	0.0239	0.025	0.025	0.0192	0.0192
Metamitron	Water	kg	0.000841	0.000841	0.0000803	0.0000803	x	x
methanol	Water	kg	0.0000473	0.0000473	0.00000452	0.00000452	x	x
methylchloride	Water	kg	0.000000399	0.000000399	3.81E-08	3.81E-08	x	x
Mg	Water	kg	0.0364	0.0364	0.0143	0.0143	0.183	0.134
Mn	Water	kg	0.00179	0.00179	0.00035	0.00035	0.00292	0.00212
Mo	Water	kg	0.0000223	0.0000223	0.00000818	0.00000818	0.0000215	0.0000182
morpholine	Water	kg	3.84E-08	3.84E-08	3.66E-09	3.66E-09	-1.48E-09	-1.55E-09
MTBE	Water	kg	1.53E-09	1.53E-09	7.55E-10	7.55E-10	6.22E-08	6.22E-08
N-tot	Water	kg	0.00445	0.00445	0.00215	0.00215	0.019	0.019
N organically bound	Water	kg	0.000012	0.000012	0.00000479	0.00000479	0.0000589	0.0000589
Na	Water	kg	6.15	6.15	0.999	0.999	2.62	2.3
NH3	Water	kg	0.000496	0.000496	0.000467	0.000467	0.000115	0.000115
NH3 (as N)	Water	kg	0.0229	0.0229	0.0133	0.0133	0.199	0.146
NH4+	Water	kg	0.00115	0.00115	0.00213	0.00213	0.00362	0.00362
Ni	Water	kg	0.00106	0.00106	0.000762	0.000762	0.000438	0.0004
nitrate	Water	kg	0.0144	0.0144	0.00792	0.00792	0.0185	0.018
nitrite	Water	kg	0.0000224	0.0000224	0.0000177	0.0000177	0.000305	0.000225
nitrogen	Water	kg	0.00877	0.00877	0.00479	0.00479	x	x
OCl-	Water	kg	0.0000116	0.0000116	0.0000026	0.0000026	0.0000064	0.0000064
oil	Water	kg	0.0158	0.0158	0.0429	0.0429	0.0105	0.0103
organic carbon	Water	kg	0.000000389	0.000000389	0.000000389	0.000000389	x	x
other organics	Water	kg	0.00137	0.00137	0.000424	0.000424	0.0867	0.0867
P	Water	kg	0.00245	0.00245	0.00165	0.00165	0.000000276	0.0000002
P-compounds	Water	kg	0.000336	0.000336	0.000225	0.000225	0.000000102	0.000000102
P-tot	Water	kg	0.00017	0.00017	0.000158	0.000158	0.000422	0.000315
P2O5	Water	kg	0.00000963	0.00000963	0.0000143	0.0000143	0.000532	0.000532
PAH's	Water	kg	0.0000075	0.0000075	0.0000163	0.0000163	0.00000863	0.00000829

Pb	Water	kg	0.00144	0.00144	0.00115	0.00115	0.00424	0.00302
PCB's	Water	kg	5.43E-09	5.43E-09	5.01E-09	5.01E-09	7.77E-08	5.31E-08
pesticides	Water	kg	0.00149	0.00149	0.001	0.001	x	x
phenol	Water	kg	0.0000849	0.0000849	0.0000233	0.0000233	0.0000325	0.0000304
phenols	Water	kg	0.0000621	0.0000621	0.000214	0.000214	0.000471	0.000471
phosphate	Water	kg	0.0321	0.0321	0.0234	0.0234	0.00646	0.00646
phosphoric acid	Water	kg	x	x	x	x	1.19E-09	1.19E-09
propylene glycol	Water	kg	0.0716	0.0716	0.00684	0.00684	x	x
Ru	Water	kg	0.000000472	0.000000472	0.000000128	0.000000128	0.000002	0.000002
S	Water	kg	0.00000221	0.00000221	0.00000221	0.00000221	0.000209	0.000209
salt	Water	kg	0.00000205	0.00000205	0.00000215	0.00000215	0.000273	0.000273
salts	Water	kg	1.38	1.38	1.19	1.19	0.00204	0.00202
Sb	Water	kg	0.00000051	0.00000051	5.72E-08	5.72E-08	4.03E-08	4.03E-08
Se	Water	kg	0.0000369	0.0000369	0.0000135	0.0000135	0.00000958	0.00000958
Si	Water	kg	0.00000179	0.00000179	0.000000651	0.000000651	0.00000205	0.00000205
Sn	Water	kg	0.00036	0.00036	0.000397	0.000397	0.0056	0.00413
SO3	Water	kg	0.00000161	0.00000161	0.000000569	0.000000569	0.0000267	0.0000267
sodium dichromate	Water	kg	1.35E-08	1.35E-08	1.35E-08	1.35E-08	x	x
Sr	Water	kg	0.00168	0.00168	0.000252	0.000252	0.00157	0.00147
sulphate	Water	kg	4.09	4.09	1.37	1.37	0.654	0.606
sulphates	Water	kg	0.0781	0.0781	0.0609	0.0609	0.0268	0.0268
sulphide	Water	kg	0.000836	0.000836	0.000159	0.000159	0.000737	0.000737
suspended solids	Water	kg	0.53	0.525	0.93	0.926	0.333	0.333
suspended substances	Water	kg	0.344	0.344	0.389	0.389	0.0386	0.0344
tetrachloroethene	Water	kg	1.14E-10	1.14E-10	2.95E-11	2.95E-11	9.59E-11	9.59E-11
tetrachloromethane	Water	kg	1.73E-10	1.73E-10	4.5E-11	4.5E-11	1.47E-10	1.47E-10
Ti	Water	kg	0.000437	0.000437	0.000161	0.000161	0.000106	0.000106
TOC	Water	kg	0.0554	0.0554	0.169	0.169	0.057	0.0569
toluene	Water	kg	0.0000716	0.0000716	0.000173	0.000173	0.0000732	0.0000712
tributyltin	Water	kg	7.18E-08	7.18E-08	2.12E-08	2.12E-08	0.000000239	0.000000239
trichloroethene	Water	kg	7.25E-09	7.25E-09	1.88E-09	1.88E-09	6.5E-09	6.5E-09
trichloromethane	Water	kg	2.65E-08	2.65E-08	1.22E-08	1.22E-08	2.24E-08	2.24E-08
triethylene glycol	Water	kg	0.0000526	0.0000526	0.0000135	0.0000135	0.00000344	0.00000274
undissolved substances	Water	kg	0.769	0.769	0.305	0.305	0.0111	0.0111
unspecified emission	Water	kg	0.000000411	0.000000411	3.92E-08	3.92E-08	-0.0000522	-0.0000522
V	Water	kg	0.0000384	0.0000384	0.0000137	0.0000137	0.0000113	0.0000113
vinyl chloride	Water	kg	3.23E-10	3.23E-10	2.99E-10	2.99E-10	0.00000906	0.00000906
VOC as C	Water	kg	0.0000911	0.0000911	0.0000127	0.0000127	0.0000926	0.0000864
W	Water	kg	0.000000188	0.000000188	6.42E-08	6.42E-08	4.14E-08	4.14E-08
waste water (vol)	Water	m3	20.8	20.8	2.09	2.09	1.56	1.16
water	Water	kg	63300	63100	61100	61000	52300	52300
xylene	Water	kg	0.000206	0.000206	0.0000238	0.0000238	0.0000806	0.0000638
Zn	Water	kg	0.00305	0.00305	0.00247	0.00247	0.013	0.00936
chemical waste	Solid	kg	0.000285	0.000285	0.000166	0.000166	0.00343	0.00294
chemical waste (inert)	Solid	kg	0.0101	0.0101	0.0244	0.0244	0.0081	0.0081
chemical waste (regulated)	Solid	kg	0.196	0.196	0.104	0.104	1.68	1.35
corr.cardboard rejects	Solid	kg	0.0302	0.0302	x	x	0.374	0.374
electrostatic filter dust	Solid	kg	x	x	x	x	0.0147	0.0147
final waste (inert)	Solid	kg	0.00717	0.00717	0.0467	0.0467	0.0252	0.0252
high active nuclear waste	Solid	m3	0.000026	0.000026	0.00000248	0.00000248	0.000000183	0.000000183
incinerator waste	Solid	kg	x	x	x	x	0.0000202	0.0000202
industrial waste	Solid	kg	0.00719	0.00719	0.00887	0.00887	0.778	0.777
inorganic general	Solid	kg	0.0399	0.0399	0.00786	0.00786	0.226	0.226
low,med. act. nucl. waste	Solid	m3	0.00229	0.00229	0.000219	0.000219	5.74E-08	5.74E-08
metal scrap	Solid	kg	0.0052	0.0052	0.0052	0.0052	0.108	0.108
mineral waste	Solid	kg	11.4	11.4	7.44	7.44	165	132
mineral waste (mining)	Solid	kg	1.43	1.43	0.214	0.214	-0.113	-0.0943

oil	Solid	kg	0.0000109	0.0000109	0.00387	0.00387	9.64E-08	9.64E-08
packaging waste	Solid	kg	x	x	x	x	0.0251	0.0251
paper/board packaging	Solid	kg	0.0499	0.0499	0.0499	0.0499	0.894	0.894
plastics waste	Solid	kg	0.000518	0.000518	0.000518	0.000518	0.0224	0.0224
process waste	Solid	kg	0.272	0.272	0.026	0.026	x	x
produc. waste (not inert)	Solid	kg	0.000414	0.000414	0.000435	0.000435	0.224	0.224
radioactive waste (kg)	Solid	kg	0.000233	0.000233	0.0000414	0.0000414	0.000662	0.000558
slag	Solid	kg	0.000323	0.000323	0.047	0.047	0.000512	0.000512
slags/ash	Solid	kg	0.261	0.261	0.0393	0.0393	1.44	1.58
sludge	Solid	kg	210	208	369	367	0.937	0.937
solid waste	Solid	kg	9.19	9.19	2.22	2.22	x	x
toxic waste	Solid	kg	0.00156	0.00156	0.00278	0.00278	x	x
unspecified	Solid	kg	x	x	x	x	0.947	0.947
waste	Solid	kg	50.9	50.9	26.7	26.7	485	374
waste bioactive landfill	Solid	kg	0.0474	0.0474	0.0291	0.0291	0.334	0.334
waste in incineration	Solid	kg	0.0211	0.0211	0.00144	0.00144	0.412	0.411
waste in inert landfill	Solid	kg	x	x	x	x	4.75	4.75
waste limestone	Solid	kg	x	x	x	x	0.411	0.411
wood waste	Solid	kg	x	x	x	x	17.6	17.6
Al (ind.)	Soil	kg	0.00012	0.00012	0.0000322	0.0000322	0.000233	0.000232
As (agr.)	Soil	kg	6.06E-11	6.06E-11	6.46E-11	6.46E-11	7.49E-10	4.04E-10
As (ind.)	Soil	kg	4.89E-08	4.89E-08	1.29E-08	1.29E-08	9.23E-08	9.23E-08
C (ind.)	Soil	kg	0.000365	0.000365	0.0000981	0.0000981	0.000722	0.00072
Ca (ind.)	Soil	kg	0.000479	0.000479	0.000129	0.000129	0.000931	0.000927
Cd	Soil	kg	5.62E-09	5.62E-09	5.36E-10	5.36E-10	5.27E-13	3.2E-13
Cd (ind.)	Soil	kg	1.25E-09	1.25E-09	4.67E-10	4.67E-10	2.05E-08	2.05E-08
Co	Soil	kg	4.76E-09	4.76E-09	4.55E-10	4.55E-10	5.58E-13	3.42E-13
Co (ind.)	Soil	kg	1.27E-09	1.27E-09	3.39E-10	3.39E-10	5.12E-09	5.12E-09
Cr	Soil	kg	0.000000328	0.000000328	3.21E-08	3.21E-08	9.37E-09	5.06E-09
Cr (ind.)	Soil	kg	0.000000311	0.000000311	0.000000133	0.000000133	0.00000116	0.00000116
Cu	Soil	kg	1.73E-08	1.73E-08	1.65E-09	1.65E-09	2.79E-12	1.71E-12
Cu (ind.)	Soil	kg	6.33E-09	6.33E-09	1.7E-09	1.7E-09	2.56E-08	2.56E-08
Fe	Soil	kg	0.000115	0.000115	0.0000113	0.0000113	0.00000372	0.00000201
Fe (ind.)	Soil	kg	0.000124	0.000124	0.0000531	0.0000531	0.000462	0.000462
fluoride	Soil	kg	0.00000949	0.00000949	0.000000907	0.000000907	x	x
Hg	Soil	kg	3.73E-08	3.73E-08	3.57E-09	3.57E-09	9.54E-14	5.78E-14
Hg (ind.)	Soil	kg	2.38E-10	2.38E-10	7.19E-11	7.19E-11	7.22E-10	7.22E-10
Mn (ind.)	Soil	kg	0.00000479	0.00000479	0.00000129	0.00000129	0.00000931	0.00000927
Mo (ind.)	Soil	kg	2.32E-09	2.32E-09	2.21E-10	2.21E-10	x	x
N	Soil	kg	0.000000117	0.000000117	3.97E-08	3.97E-08	0.000000216	0.000000216
Ni	Soil	kg	1.77E-08	1.77E-08	1.69E-09	1.69E-09	4.19E-12	2.57E-12
Ni (ind.)	Soil	kg	9.49E-09	9.49E-09	2.55E-09	2.55E-09	3.84E-08	3.84E-08
oil (ind.)	Soil	kg	0.0000417	0.0000417	0.0000112	0.0000112	0.000167	0.000167
oil biodegradable	Soil	kg	0.000000655	0.000000655	0.000000235	0.000000235	0.000000487	0.000000487
P-tot	Soil	kg	0.00000523	0.00000523	0.00000161	0.00000161	0.0000119	0.0000119
Pb	Soil	kg	6.41E-08	6.41E-08	6.13E-09	6.13E-09	1.27E-11	7.8E-12
Pb (ind.)	Soil	kg	0.000000029	0.000000029	7.79E-09	7.79E-09	0.000000119	0.000000119
phosphor (ind.)	Soil	kg	0.00000119	0.00000119	0.000000157	0.000000157	x	x
S (ind.)	Soil	kg	0.0000719	0.0000719	0.0000193	0.0000193	0.00014	0.000139
selenium (ind.)	Soil	kg	1.43E-09	1.43E-09	1.37E-10	1.37E-10	x	x
thallium (ind.)	Soil	kg	1.39E-10	1.39E-10	1.32E-11	1.32E-11	x	x
tin (ind.)	Soil	kg	1.66E-09	1.66E-09	1.59E-10	1.59E-10	x	x
vanadium (ind.)	Soil	kg	5.53E-08	5.53E-08	5.28E-09	5.28E-09	x	x
Zn (ind.)	Soil	kg	0.00000199	0.00000199	0.000000511	0.000000511	0.00000375	0.00000373
Ag110m to air	Non mat.	Bq	0.0000294	0.0000294	0.00000646	0.00000646	0.0000161	0.0000161
Ag110m to water	Non mat.	Bq	0.201	0.201	0.044	0.044	0.11	0.11
alpha radiation (unspecified) to water	Non mat.	Bq	0.0000238	0.0000238	0.00000522	0.00000522	13.1	13.1
Am241 to air	Non mat.	Bq	0.000549	0.000549	0.00012	0.00012	0.00042	0.00042
Am241 to water	Non mat.	Bq	0.0723	0.0723	0.0159	0.0159	13	13
Ar41 to air	Non mat.	Bq	64	64	14	14	34.9	34.9
Ba140 to air	Non mat.	Bq	0.000115	0.000115	0.0000253	0.0000253	0.000948	0.000948

Ba140 to water	Non mat.	Bq	0.000363	0.000363	0.0000809	0.0000809	0.000216	0.000216
beta radiation (unspecified) to air	Non mat.	Bq	0.0000037	0.0000037	0.000000824	0.000000824	0.00000216	0.00000216
C14 to air	Non mat.	Bq	44	44	9.69	9.69	120	120
C14 to water	Non mat.	Bq	3.65	3.65	0.802	0.802	782	782
Cd109 to water	Non mat.	Bq	0.0000021	0.0000021	0.000000468	0.000000468	0.00000125	0.00000125
Ce141 to air	Non mat.	Bq	0.00000275	0.00000275	0.0000006	0.0000006	0.000245	0.000245
Ce141 to water	Non mat.	Bq	0.0000543	0.0000543	0.0000121	0.0000121	0.0000323	0.0000323
Ce144 to air	Non mat.	Bq	0.00584	0.00584	0.00128	0.00128	0.00567	0.00567
Ce144 to water	Non mat.	Bq	1.65	1.65	0.363	0.363	610	610
Cm (alpha) to air	Non mat.	Bq	0.00087	0.00087	0.000191	0.000191	0.000497	0.000497
Cm (alpha) to water	Non mat.	Bq	0.0958	0.0958	0.021	0.021	24.8	24.8
Cm242 to air	Non mat.	Bq	2.91E-09	2.91E-09	6.34E-10	6.34E-10	1.58E-09	1.58E-09
Cm244 to air	Non mat.	Bq	2.63E-08	2.63E-08	5.76E-09	5.76E-09	1.44E-08	1.44E-08
Co57 to air	Non mat.	Bq	5.07E-08	5.07E-08	1.11E-08	1.11E-08	2.76E-08	2.76E-08
Co57 to water	Non mat.	Bq	0.000371	0.000371	0.0000831	0.0000831	0.000222	0.000222
Co58 to air	Non mat.	Bq	0.000837	0.000837	0.000184	0.000184	0.00056	0.00056
Co58 to water	Non mat.	Bq	0.313	0.313	0.0694	0.0694	0.178	0.178
Co60 to air	Non mat.	Bq	0.00125	0.00125	0.000273	0.000273	0.00437	0.00437
Co60 to water	Non mat.	Bq	16	16	3.51	3.51	3620	3620
Conv. to industrial area	Non mat.	m2	0.0000207	0.0000207	0.000438	0.000438	0.0000245	0.0000245
Cr51 to air	Non mat.	Bq	0.000104	0.000104	0.0000227	0.0000227	0.000357	0.000357
Cr51 to water	Non mat.	Bq	0.00798	0.00798	0.00178	0.00178	0.00562	0.00562
Cs134 to air	Non mat.	Bq	0.0208	0.0208	0.00457	0.00457	0.0196	0.0196
Cs134 to water	Non mat.	Bq	3.7	3.7	0.811	0.811	1730	1730
Cs136 to water	Non mat.	Bq	0.00000195	0.00000195	0.000000434	0.000000434	0.00000116	0.00000116
Cs137 to air	Non mat.	Bq	0.0403	0.0403	0.00883	0.00883	0.0388	0.0388
Cs137 to water	Non mat.	Bq	34	34	7.47	7.47	10300	10300
Fe59 to air	Non mat.	Bq	0.00000114	0.00000114	0.000000251	0.000000251	0.00004	0.00004
Fe59 to water	Non mat.	Bq	0.00000642	0.00000642	0.00000143	0.00000143	0.00000382	0.00000382
Fission and activation products (RA) to water	Non mat.	Bq	0.216	0.216	0.0475	0.0475	0.119	0.119
H3 to air	Non mat.	Bq	456	456	99.9	99.9	249	249
H3 to water	Non mat.	Bq	108000	108000	23800	23800	59400	59400
heat losses to air	Non mat.	MJ	0.555	0.555	0.583	0.583	3.29	3.29
heat losses to soil	Non mat.	MJ	0.000217	0.000217	0.000229	0.000229	0.141	0.141
heat losses to water	Non mat.	MJ	0.0426	0.0426	0.0448	0.0448	0.0655	0.0655
I129 to air	Non mat.	Bq	0.157	0.157	0.0344	0.0344	0.126	0.126
I129 to water	Non mat.	Bq	10.5	10.5	2.29	2.29	2290	2290
I131 to air	Non mat.	Bq	0.0174	0.0174	0.00385	0.00385	0.114	0.114
I131 to water	Non mat.	Bq	0.00692	0.00692	0.00153	0.00153	0.00569	0.00569
I133 to air	Non mat.	Bq	0.00974	0.00974	0.00214	0.00214	0.00533	0.00533
I133 to water	Non mat.	Bq	0.00166	0.00166	0.000371	0.000371	0.000986	0.000986
I135 to air	Non mat.	Bq	0.0146	0.0146	0.0032	0.0032	0.00797	0.00797
K40 to air	Non mat.	Bq	0.11	0.11	0.0301	0.0301	0.053	0.053
K40 to water	Non mat.	Bq	0.262	0.262	0.0576	0.0576	0.151	0.151
Kr85 to air	Non mat.	Bq	2700000	2700000	592000	592000	2070000	2070000
Kr85m to air	Non mat.	Bq	3.19	3.19	0.709	0.709	1.85	1.85
Kr87 to air	Non mat.	Bq	1.43	1.43	0.316	0.316	0.811	0.811
Kr88 to air	Non mat.	Bq	127	127	27.9	27.9	69.7	69.7
Kr89 to air	Non mat.	Bq	1	1	0.223	0.223	0.579	0.579
La140 to air	Non mat.	Bq	0.0000729	0.0000729	0.000016	0.000016	0.00249	0.00249
La140 to water	Non mat.	Bq	0.0000752	0.0000752	0.0000167	0.0000167	0.0000447	0.0000447
land use (sea floor) II-III	Non mat.	m2a	0.0759	0.0759	0.033	0.033	0.281	0.281
land use (sea floor) II-IV	Non mat.	m2a	0.00783	0.00783	0.00341	0.00341	0.029	0.029
land use II-III	Non mat.	m2a	0.314	0.314	0.0736	0.0736	0.273	0.273
land use II-IV	Non mat.	m2a	0.0193	0.0193	0.0123	0.0123	0.423	0.423
land use III-IV	Non mat.	m2a	0.0194	0.0194	0.0128	0.0128	0.859	0.859
land use IV-IV	Non mat.	m2a	0.000649	0.000649	0.000221	0.000221	0.000308	0.000308
Mn54 to air	Non mat.	Bq	0.0000299	0.0000299	0.00000657	0.00000657	0.000523	0.000523
Mn54 to water	Non mat.	Bq	2.45	2.45	0.538	0.538	1.35	1.35
Mo99 to water	Non mat.	Bq	0.0000253	0.0000253	0.00000566	0.00000566	0.0000151	0.0000151
Na24 to water	Non mat.	Bq	0.0112	0.0112	0.0025	0.0025	0.00665	0.00665

Nb95 to air	Non mat.	Bq	0.00000528	0.00000528	0.00000116	0.00000116	0.000309	0.000309
Nb95 to water	Non mat.	Bq	0.000206	0.000206	0.000046	0.000046	0.000323	0.000323
Np237 to air	Non mat.	Bq	2.88E-08	2.88E-08	6.3E-09	6.3E-09	4.62E-08	4.62E-08
Np237 to water	Non mat.	Bq	0.00462	0.00462	0.00101	0.00101	8.56	8.56
Occup. as contin. urban land	Non mat.	m2a	0.0000737	0.0000737	0.0000775	0.0000775	x	x
Occup. as convent. arable land	Non mat.	m2a	0.0009	0.0009	0.000946	0.000946	x	x
Occup. as forest land	Non mat.	m2a	0.000000104	0.000000104	0.000000109	0.000000109	x	x
Occup. as industrial area	Non mat.	m2a	0.0773	0.0773	0.212	0.212	0.401	0.401
Occup. as rail/road area	Non mat.	m2a	1.3	1.3	4.47	4.47	2.06	2.06
Pa234m to air	Non mat.	Bq	0.0174	0.0174	0.00383	0.00383	0.0202	0.0202
Pa234m to water	Non mat.	Bq	0.323	0.323	0.0708	0.0708	0.375	0.375
Pb210 to air	Non mat.	Bq	0.583	0.583	0.149	0.149	0.292	0.292
Pb210 to water	Non mat.	Bq	0.209	0.209	0.0459	0.0459	0.12	0.12
Pm147 to air	Non mat.	Bq	0.0148	0.0148	0.00325	0.00325	0.00812	0.00812
Po210 to air	Non mat.	Bq	0.905	0.905	0.237	0.237	0.447	0.447
Po210 to water	Non mat.	Bq	0.209	0.209	0.0459	0.0459	0.12	0.12
Pu alpha to air	Non mat.	Bq	0.00174	0.00174	0.000382	0.000382	0.0014	0.0014
Pu alpha to water	Non mat.	Bq	0.288	0.288	0.063	0.063	209	209
Pu238 to air	Non mat.	Bq	6.54E-08	6.54E-08	1.44E-08	1.44E-08	3.57E-08	3.57E-08
Pu241 beta	Non mat.	Bq	6.45	6.45	1.48	1.48	6280	6280
Pu241 Beta to air	Non mat.	Bq	0.0478	0.0478	0.0105	0.0105	0.0369	0.0369
Pu241 beta to water	Non mat.	Bq	0.695	0.695	0.09	0.09	x	x
Ra224 to water	Non mat.	Bq	2.33	2.33	0.63	0.63	9.98	9.98
Ra226 to air	Non mat.	Bq	0.647	0.647	0.147	0.147	0.58	0.58
Ra226 to water	Non mat.	Bq	1340	1340	293	293	749	749
Ra228 to air	Non mat.	Bq	0.0543	0.0543	0.0149	0.0149	0.0261	0.0261
Ra228 to water	Non mat.	Bq	4.67	4.67	1.26	1.26	19.9	19.9
radio active noble gases to air	Non mat.	Bq	3.84	3.84	0.856	0.856	2.28	2.28
radioactive substance to air	Non mat.	Bq	313000000	313000000	376000000	376000000	91500000	91500000
radioactive substance to water	Non mat.	Bq	2860000	2860000	3450000	3450000	17200000	17200000
radionuclides (mixed) to water	Non mat.	Bq	0.000156	0.000156	0.0000343	0.0000343	7.44	7.44
Rn220 to air	Non mat.	Bq	4.24	4.24	1.02	1.02	7.46	7.46
Rn222 (long term) to air	Non mat.	Bq	3870000	3870000	851000	851000	2130000	2130000
Rn222 to air	Non mat.	Bq	42200	42200	9270	9270	2190000	2190000
Ru103 to air	Non mat.	Bq	0.000000299	0.000000299	6.56E-08	6.56E-08	0.000244	0.000244
Ru103 to water	Non mat.	Bq	0.000121	0.000121	0.0000272	0.0000272	0.00012	0.00012
Ru106 to air	Non mat.	Bq	0.174	0.174	0.0382	0.0382	0.476	0.476
Ru106 to water	Non mat.	Bq	17.4	17.4	3.82	3.82	22800	22800
Sb122 to water	Non mat.	Bq	0.000363	0.000363	0.0000809	0.0000809	0.000216	0.000216
Sb124 to air	Non mat.	Bq	0.00000808	0.00000808	0.00000177	0.00000177	0.00000586	0.00000586
Sb124 to water	Non mat.	Bq	0.0518	0.0518	0.0114	0.0114	0.0305	0.0305
Sb125 to air	Non mat.	Bq	0.00000103	0.00000103	0.000000228	0.000000228	0.000000586	0.000000586
Sb125 to water	Non mat.	Bq	0.00297	0.00297	0.000662	0.000662	0.002	0.002
Sr89 to air	Non mat.	Bq	0.0000523	0.0000523	0.0000115	0.0000115	0.0000286	0.0000286
Sr89 to water	Non mat.	Bq	0.00082	0.00082	0.000183	0.000183	0.000489	0.000489
Sr90 to air	Non mat.	Bq	0.0288	0.0288	0.00631	0.00631	0.0277	0.0277
Sr90 to water	Non mat.	Bq	3.49	3.49	0.764	0.764	4570	4570
Tc99 to air	Non mat.	Bq	0.00000122	0.00000122	0.000000267	0.000000267	0.00000221	0.00000221
Tc99 to water	Non mat.	Bq	1.83	1.83	0.401	0.401	401	401
Tc99m to water	Non mat.	Bq	0.000171	0.000171	0.0000382	0.0000382	0.000102	0.000102
Te123m to air	Non mat.	Bq	0.000132	0.000132	0.0000288	0.0000288	0.0000719	0.0000719
Te123m to water	Non mat.	Bq	0.0000153	0.0000153	0.00000342	0.00000342	0.00000914	0.00000914
Te132 to water	Non mat.	Bq	0.00000626	0.00000626	0.0000014	0.0000014	0.00000373	0.00000373
Th228 to air	Non mat.	Bq	0.046	0.046	0.0126	0.0126	0.0221	0.0221
Th228 to water	Non mat.	Bq	9.33	9.33	2.52	2.52	39.9	39.9
Th230 to air	Non mat.	Bq	0.194	0.194	0.0425	0.0425	79.3	79.3
Th230 to water	Non mat.	Bq	50.4	50.4	11.1	11.1	27.7	27.7

Th232 to air	Non mat.	Bq	0.0292	0.0292	0.008	0.008	0.014	0.014
Th232 to water	Non mat.	Bq	0.0488	0.0488	0.0107	0.0107	0.0281	0.0281
Th234 to air	Non mat.	Bq	0.0174	0.0174	0.00383	0.00383	0.0202	0.0202
Th234 to water	Non mat.	Bq	0.326	0.326	0.0714	0.0714	0.376	0.376
U alpha to air	Non mat.	Bq	0.624	0.624	0.137	0.137	0.342	0.342
U alpha to water	Non mat.	Bq	21.1	21.1	4.63	4.63	11.5	11.5
U234 to air	Non mat.	Bq	0.209	0.209	0.0459	0.0459	0.128	0.128
U234 to water	Non mat.	Bq	0.432	0.432	0.0945	0.0945	0.236	0.236
U235 to air	Non mat.	Bq	0.0101	0.0101	0.00222	0.00222	0.00621	0.00621
U235 to water	Non mat.	Bq	0.643	0.643	0.141	0.141	0.352	0.352
U238 to air	Non mat.	Bq	0.289	0.289	0.0681	0.0681	0.602	0.602
U238 to water	Non mat.	Bq	1.09	1.09	0.24	0.24	52.8	52.8
waste heat to air	Non mat.	MJ	124	124	48.8	48.8	339	339
waste heat to soil	Non mat.	MJ	0.207	0.207	0.048	0.048	0.139	0.139
waste heat to water	Non mat.	MJ	47.4	47.4	16.9	16.9	46.6	46.6
Xe131m to air	Non mat.	Bq	6.61	6.61	1.46	1.46	3.74	3.74
Xe133 to air	Non mat.	Bq	1940	1940	426	426	1060	1060
Xe133m to air	Non mat.	Bq	0.976	0.976	0.214	0.214	0.533	0.533
Xe135 to air	Non mat.	Bq	331	331	72.6	72.6	183	183
Xe135m to air	Non mat.	Bq	32.7	32.7	7.24	7.24	18.8	18.8
Xe137 to air	Non mat.	Bq	0.811	0.811	0.179	0.179	0.462	0.462
Xe138 to air	Non mat.	Bq	8.87	8.87	1.96	1.96	5.1	5.1
Y90 to water	Non mat.	Bq	0.0000419	0.0000419	0.00000936	0.00000936	0.000025	0.000025
Zn65 to air	Non mat.	Bq	0.000128	0.000128	0.0000282	0.0000282	0.0196	0.0196
Zn65 to water	Non mat.	Bq	0.0236	0.0236	0.00526	0.00526	0.0145	0.0145
Zr95 to air	Non mat.	Bq	0.00000192	0.00000192	0.00000042	0.00000042	0.000226	0.000226
Zr95 to water	Non mat.	Bq	0.148	0.148	0.0325	0.0325	38.1	38.1

Annex B

Impact Assessment Method (Includes Characterisation Factors)

Introduction

Extracted From Simapro

Name CML 2 baseline 2000 ERM Correction Acidification: NOx attributed a CF factor

Comment This method is an update from the CML 1992 method. This version is based on the spreadsheet version 2.02 (September 2001) as published on the CML web site and replaces the preliminary version.

The CML 2 baseline method elaborates the problem-oriented (midpoint) approach. The CML Guide provides a list of impact assessment categories grouped into
A: Obligatory impact categories (Category indicators used in most LCAs)
B: Additional impact categories (operational indicators exist, but are not often included in LCA studies)
C: Other impact categories (no operational indicators available, therefore impossible to include quantitatively in LCA)

In case several methods are available for obligatory impact categories, a baseline indicator is selected, based on the principle of best available practice. These baseline indicators are category indicators at "mid-point level" (problem oriented approach)". Baseline indicators are recommended for simplified studies. The guide provides guidelines for inclusion of other methods and impact category indicators in case of detailed studies and extended studies.
Only baseline indicators are available in the CML method in SimaPro (based on CML Excel spreadsheet with characterisation and normalisation factors). In general, these indicators do not deviate from the ones in the spreadsheet. In case the spreadsheet contained synonyms of substance names already available in the substance list of the SimaPro database, the existing names are used. A distinction is made for emissions to agricultural soil and industrial soil, indicated with respectively (agr.) or (ind.) behind substance names emitted to soil. Emissions to seawater are indicated with (sea), while emissions to fresh water have no addition behind their substance name (we assume that all emissions to water in existing process records are emissions to fresh water).

Depletion of abiotic resources
This impact category indicator is related to extraction of minerals and fossil fuels due to inputs in the system. The Abiotic Depletion Factor (ADF) is determined for each extraction of minerals and fossil fuels (kg antimony equivalents/kg extraction) based on concentration reserves and rate of deaccumulation.

Climate change
The characterisation model as developed by the Intergovernmental Panel on Climate Change (IPCC) is selected for development of characterisation factors. Factors are expressed as Global Warming Potential for time horizon 100 years (GWP100), in kg carbon dioxide/kg emission.

Stratospheric Ozone depletion

The characterisation model is developed by the World Meteorological Organisation (WMO) and defines ozone depletion potential of different gasses (kg CFC-11 equivalent/ kg emission).

Human toxicity
Characterisation factors, expressed as Human Toxicity Potentials (HTP), are calculated with USES-LCA, describing fate, exposure and effects of toxic substances for an infinite time horizon. For each toxic substance HTP's are expressed as 1,4-dichlorobenzene equivalents/ kg emission.

Fresh-water aquatic eco-toxicity
Eco-toxicity Potential (FAETP) are calculated with USES-LCA, describing fate, exposure and effects of toxic substances. Characterisation factors are expressed as 1,4-dichlorobenzene equivalents/ kg emission.

Marine aquatic ecotoxicity
Marine eco-toxicity refers to impacts of toxic substances on marine ecosystems (see description fresh water toxicity).

Terrestrial ecotoxicity
This category refers to impacts of toxic substances on terrestrial ecosystems (see description fresh water toxicity).

Photo-oxidant formation
Photochemical Ozone Creation Potential (POCP) (also known as summer smog) for emission of substances to air is calculated with the UNECE Trajectory model (including fate), and expressed in kg ethylene equivalents/kg emission. Acidification
Acidification Potentials (AP) is expressed as kg SO2 equivalents/ kg emission.

Eutrophication
Nutrification potential (NP) is based on the stoichiometric procedure of Heijungs (1992), and expressed as kg PO4 equivalents/ kg emission. Normalisation
For each baseline indicator, normalisation scores are calculated for the reference situations: the world in 1990, Europe in 1995 and the Netherlands in 1997. Normalisation data are described in the report: Huijbregts et al LCA normalisation data for the Netherlands (1997/1998), Western Europe (1995) and the World (1990 and 1995).

Grouping and weighting
Grouping and weighting are considered to be optional step. No baseline recommended rules or values are given for these steps. Based on the reports:
"Life Cycle Assessment. An operational Guide to ISO Standards" Centre of Environmental Science (CML), Leiden University, the Netherlands. Download from http://www.leidenuniv.nl/cml/lca2/index.html.

May 01 Characterisation for sum parameters metals added. October 2001 Version 2.02 update.

Table B1.1 Abiotic Depletion

Impact category	Abiotic resource depletion	kg Sb eq	
Raw	aluminium (in ore)	kg	0.00000001
Raw	argon	kg	0.000000471
Raw	bauxite	kg	2.1E-09
Raw	chromium (in ore)	kg	0.000858
Raw	chromium (ore)	kg	0.000257522
Raw	coal	kg	0.0134
Raw	coal ETH	kg	0.0134
Raw	coal FAL	kg	0.0134
Raw	cobalt (in ore)	kg	0.0000262
Raw	copper (in ore)	kg	0.00194
Raw	copper (ore)	kg	2.19642E-05
Raw	crude oil	kg	0.0201
Raw	crude oil (feedstock)	kg	0.0201
Raw	crude oil ETH	kg	0.0201
Raw	crude oil FAL	kg	0.0201
Raw	crude oil IDEMAT	kg	0.0201
Raw	energy from coal	MJ	0.000457
Raw	energy from lignite	MJ	0.000671
Raw	energy from natural gas	MJ	0.000534
Raw	energy from oil	MJ	0.00049
Raw	iron (in ore)	kg	8.43E-08
Raw	iron (ore)	kg	0.000000048
Raw	lead (in ore)	kg	0.0135
Raw	lead (ore)	kg	0.000676957
Raw	lignite	kg	0.00671
Raw	lignite ETH	kg	0.00671
Raw	magnesium (in ore)	kg	3.73E-09
Raw	manganese (in ore)	kg	0.0000138
Raw	manganese (ore)	kg	0.0000062
Raw	mercury (in ore)	kg	0.495
Raw	molybdene (in ore)	kg	0.0317
Raw	molybdenum (ore)	kg	3.16646E-05
Raw	natural gas	kg	0.0225
Raw	natural gas (feedstock)	m3	0.0187
Raw	natural gas (vol)	m3	0.0187
Raw	natural gas ETH	m3	0.0187
Raw	natural gas FAL	kg	0.0225
Raw	nickel (in ore)	kg	0.000108
Raw	nickel (ore)	kg	1.61394E-06
Raw	palladium (in ore)	kg	0.323
Raw	platinum (in ore)	kg	1.29
Raw	K	kg	3.13E-08
Raw	silicon	kg	2.99E-11
Raw	silver	kg	1.84
Raw	sulphur	kg	0.000358
Raw	tin (in ore)	kg	0.033
Raw	tin (ore)	kg	0.0000033
Raw	uranium (in ore)	kg	0.00287
Raw	uranium FAL	kg	0.00287
Raw	zinc (in ore)	kg	0.000992
Raw	zinc (ore)	kg	3.94812E-05
Raw	polonium (in ore)	kg	4.79E+14
Raw	krypton	kg	20.9
Raw	protactinium (in ore)	kg	9770000
Raw	radon	kg	1.2E+20
Raw	xenon	kg	17500
Raw	radium (in ore)	kg	23600000
Raw	calcium (Ca)	kg	7.08E-10
Raw	actinium (in ore)	kg	6.33E+13
Raw	thulium (in ore)	kg	0.0000831
Raw	vanadium (in ore)	kg	0.00000116
Raw	erbium (in ore)	kg	0.00000244
Raw	praseodymium (in ore)	kg	0.000000285
Raw	niobium (in ore)	kg	0.0000231
Raw	holmium (in ore)	kg	0.0000133
Raw	lutetium (in ore)	kg	0.0000766
Raw	bismuth (in ore)	kg	0.0731
Raw	F	kg	0.00000296
Raw	thorium (in ore)	kg	0.000000208
Raw	lanthanum (in ore)	kg	2.13E-08
Raw	thallium (in ore)	kg	0.0000505
Raw	iridium (in ore)	kg	32.3
Raw	rubidium (in ore)	kg	2.36E-09
Raw	arsenic (in ore)	kg	0.00917
Raw	osmium (in ore)	kg	14.4
Raw	ruthenium (in ore)	kg	32.3
Raw	cadmium (in ore)	kg	0.33
Raw	ytterbium (in ore)	kg	0.00000213
Raw	Na	kg	8.24E-11
Raw	hafnium (in ore)	kg	0.000000867
Raw	tantalum (in ore)	kg	0.0000677
Raw	gadolinium (in ore)	kg	0.000000657
Raw	neon	kg	0.325
Raw	lithium (in ore)	kg	0.00000923
Raw	strontium (in ore)	kg	0.00000112
Raw	cesium (in ore)	kg	0.0000191
Raw	dysprosium (in ore)	kg	0.00000213
Raw	antimony (in ore)	kg	1
Raw	gallium (in ore)	kg	0.000000103
Raw	samarium (in ore)	kg	0.000000532
Raw	terbium (in ore)	kg	0.0000236
Raw	boron (in ore)	kg	0.00467
Raw	indium (in ore)	kg	0.00903
Raw	phosphor (in ore)	kg	0.0000844
Raw	helium	kg	148
Raw	germanium (in ore)	kg	0.00000147
Raw	titanium (in ore)	kg	0.000000044

Impact category	Abiotic resource depletion	kg Sb eq	
Raw	scandium (in ore)	kg	3.96E-08
Raw	europium (in ore)	kg	0.0000133
Raw	barium (in ore)	kg	1.06E-10
Raw	tellerium (in ore)	kg	52.8
Raw	selenium (in ore)	kg	0.475
Raw	neodymium (in ore)	kg	1.94E-17
Raw	Cl	kg	4.86E-08
Raw	zirconium (in ore)	kg	0.0000186
Raw	beryllium (in ore)	kg	0.0000319
Raw	yttrium (in ore)	kg	0.000000334
Raw	tungsten (in ore)	kg	0.0117
Raw	gold (in ore)	kg	89.5
Raw	cerium (in ore)	kg	5.32E-09
Raw	Br	kg	0.00667
Raw	natural gas (feedstock) FAL	kg	0.0225
Raw	crude oil (feedstock) FAL	kg	0.0201
Raw	coal (feedstock) FAL	kg	0.0134
Raw	uranium (in ore) ETH	kg	0.00287
Raw	rhodium (in ore)	kg	32.3
Raw	rhenium (in ore)	kg	0.766

Table B1.2 Global Warming Potential

Impact category	Global warming (GWP100)		kg CO2 eq
Air	1,1,1-trichloroethane	kg	110
Air	CFC-14	kg	6500
Air	CFC-11	kg	4000
Air	CFC-113	kg	5000
Air	CFC-114	kg	9300
Air	CFC-115	kg	9300
Air	CFC-116	kg	9200
Air	CFC-12	kg	8500
Air	CFC-13	kg	11700
Air	CO2	kg	1
Air	CO2 (fossil)	kg	1
Air	dichloromethane	kg	9
Air	HALON-1301	kg	5600
Air	HCFC-123	kg	93
Air	HCFC-124	kg	480
Air	HCFC-141b	kg	630
Air	HCFC-142b	kg	2000
Air	HCFC-22	kg	1700
Air	HCFC-225ca	kg	170
Air	HCFC-225cb	kg	530
Air	HFC-125	kg	2800
Air	HFC-134	kg	1000
Air	HFC-134a	kg	1300
Air	HFC-143	kg	300
Air	HFC-143a	kg	3800
Air	HFC-152a	kg	140
Air	HFC-227ea	kg	2900
Air	HFC-23	kg	11700
Air	HFC-236fa	kg	6300
Air	HFC-245ca	kg	560
Air	HFC-32	kg	650
Air	HFC-41	kg	13000
Air	HFC-4310mee	kg	1300
Air	methane	kg	21
Air	N2O	kg	310
Air	perfluorbutane	kg	7000
Air	perfluorcyclobutane	kg	8700
Air	perfluorhexane	kg	7400
Air	perfluorpentane	kg	7500
Air	perfluorpropane	kg	7000
Air	SF6	kg	23900
Air	tetrachloromethane	kg	1400
Air	trichloromethane	kg	4

Table B1.3 Ozone Layer Depletion

Impact category	Ozone layer depletion (ODP)	kg CFC-11 eq	
Air	1,1,1-trichloroethane	kg	0.11
Air	CFC-11	kg	1
Air	CFC-113	kg	0.9
Air	CFC-114	kg	0.85
Air	CFC-115	kg	0.4
Air	CFC-12	kg	0.82
Air	HALON-1201	kg	1.4
Air	HALON-1202	kg	1.25
Air	HALON-1211	kg	5.1
Air	HALON-1301	kg	12
Air	HALON-2311	kg	0.14
Air	HALON-2401	kg	0.25
Air	HALON-2402	kg	7
Air	HCFC-123	kg	0.012
Air	HCFC-124	kg	0.026
Air	HCFC-141b	kg	0.086
Air	HCFC-142b	kg	0.043
Air	HCFC-22	kg	0.034
Air	HCFC-225ca	kg	0.017
Air	HCFC-225cb	kg	0.017
Air	methyl bromide	kg	0.37
Air	methyl chloride	kg	0.02
Air	tetrachloromethane	kg	1.2

Table B1.4 Human Toxicity

Impact category	x Human toxicity	kg 1,4-DB eq	
Air	1,1,1-trichloroethane	kg	16
Air	1,2,3-trichlorobenzene	kg	130
Air	1,2,4-trichlorobenzene	kg	120
Air	1,2-dichloroethane	kg	6.8
Air	1,3,5-trichlorobenzene	kg	120
Air	1,3-butadiene	kg	2200
Air	2,4,6-trichlorophenol	kg	14000
Air	2,4-D	kg	6.6
Air	acrolein	kg	57
Air	acrylonitrile	kg	3400
Air	Aldrin	kg	19
Air	ammonia	kg	0.1
Air	As	kg	350000
Air	Atrazine	kg	4.5
Air	Azinphos-methyl	kg	14
Air	Ba	kg	760
Air	Be	kg	230000
Air	Bentazon	kg	2.1
Air	benzene	kg	1900
Air	benzylchloride	kg	3500
Air	Carbendazim	kg	19
Air	Cd	kg	150000
Air	cobalt	kg	17000
Air	Cr (III)	kg	650
Air	Cr (VI)	kg	3400000
Air	CS2	kg	2.4
Air	Cu	kg	4300
Air	di(2-ethylhexyl)phthalate	kg	2.6
Air	dibutylphthalate	kg	25
Air	dichloromethane	kg	2
Air	Dichlorvos	kg	100
Air	Dieldrin	kg	13000
Air	dioxin (TEQ)	kg	1900000000
Air	Diuron	kg	210
Air	DNOC	kg	160
Air	dust (PM10)	kg	0.82
Air	ethene	kg	0.64
Air	ethylbenzene	kg	0.97
Air	ethylene oxide	kg	14000
Air	Fentin-acetate	kg	2200
Air	formaldehyde	kg	0.83
Air	H2S	kg	0.22
Air	HCl	kg	0.5
Air	heavy metals	kg	1634
Air	hexachlorobenzene	kg	3200000
Air	HF	kg	2900
Air	Hg	kg	6000
Air	m-xylene	kg	0.027
Air	Malathion	kg	0.035
Air	Mecoprop	kg	120
Air	Metabenzthiazuron	kg	7.1
Air	metals	kg	1634
Air	Metamitron	kg	0.88
Air	methyl bromide	kg	350
Air	Mevinfos	kg	1
Air	Mo	kg	5400
Air	naphthalene	kg	8.1
Air	Ni	kg	35000
Air	NO2	kg	1.2
Air	NOx (as NO2)	kg	1.2
Air	o-xylene	kg	0.12
Air	p-xylene	kg	0.043
Air	PAH's	kg	570000
Air	Pb	kg	470
Air	pentachlorophenol	kg	5.1
Air	phenol	kg	0.52
Air	phthalic acid anhydride	kg	0.41
Air	propyleneoxide	kg	1300
Air	Sb	kg	6700
Air	Se	kg	48000
Air	Simazine	kg	33
Air	Sn	kg	1.7
Air	SO2	kg	0.096
Air	styrene	kg	0.047
Air	tetrachloroethene	kg	5.5
Air	tetrachloromethane	kg	220
Air	Thiram	kg	19
Air	Tl	kg	430000
Air	toluene	kg	0.33
Air	trichloroethene	kg	34
Air	trichloromethane	kg	13
Air	Trifluralin	kg	1.7
Air	V	kg	6200
Air	vinyl chloride	kg	84
Air	Zn	kg	100
Water	1,2,3-trichlorobenzene	kg	130
Water	1,2,4-trichlorobenzene	kg	120
Water	1,2-dichloroethane	kg	28
Water	1,3,5-trichlorobenzene	kg	120
Water	1,3-butadiene	kg	7000
Water	2,4,6-trichlorophenol	kg	9100
Water	2,4-D	kg	3.5
Water	acrylonitrile	kg	7100

Impact category	x Human toxicity	kg 1,4-DB eq	
Water	Aldrin	kg	6000
Water	As	kg	950
Water	Atrazine	kg	4.6
Water	Azinphos-methyl	kg	2.5
Water	Ba	kg	630
Water	Be	kg	14000
Water	Bentazon	kg	0.73
Water	benzene	kg	1800
Water	benzylchloride	kg	2400
Water	Carbendazim	kg	2.5
Water	Cd	kg	23
Water	Co	kg	97
Water	Cr (III)	kg	2.1
Water	Cr (VI)	kg	3.4
Water	Cu	kg	1.3
Water	di(2-ethylhexyl)phthalate	kg	0.91
Water	dibutylphthalate	kg	0.54
Water	dichloromethane	kg	1.8
Water	Dichlorvos	kg	0.34
Water	Dieldrin	kg	45000
Water	dioxins (TEQ)	kg	860000000
Water	Diuron	kg	53
Water	DNOC	kg	59
Water	ethyl benzene	kg	0.83
Water	ethylene oxide	kg	11000
Water	formaldehyde	kg	0.037
Water	hexachlorobenzene	kg	5600000
Water	Hg	kg	1400
Water	Malathion	kg	0.24
Water	Mecoprop	kg	200
Water	metallic ions	kg	3.511
Water	Metamitron	kg	0.16
Water	Mevinfos	kg	11
Water	Mo	kg	5500
Water	Ni	kg	330
Water	PAH's	kg	280000
Water	Pb	kg	12
Water	pentachlorophenol	kg	7.2
Water	phenol	kg	0.049
Water	propylene oxide	kg	2600
Water	Sb	kg	5100
Water	Se	kg	56000
Water	Simazine	kg	9.7
Water	Sn	kg	0.017
Water	styrene	kg	0.085
Water	tetrachloroethene	kg	5.7
Water	tetrachloromethane	kg	220
Water	Thiram	kg	3.3
Water	toluene	kg	0.3
Water	trichloroethene	kg	33
Water	trichloromethane	kg	13
Water	Trifluralin	kg	97
Water	V	kg	3200
Water	vinyl chloride	kg	140
Water	Zn	kg	0.58
Soil	1,2,3-trichlorobenzene (ind.)	kg	54
Soil	1,2,4-trichlorobenzene (ind.)	kg	43
Soil	1,2-dichloroethane (ind.)	kg	5.7
Soil	1,3,5-trichlorobenzene (ind.)	kg	52
Soil	1,3-butadiene (ind.)	kg	2200
Soil	2,4,6-trichlorophenol (ind.)	kg	170
Soil	2,4-D (agr.)	kg	47
Soil	acrylonitrile (ind.)	kg	1500
Soil	Aldrin (agr.)	kg	4700
Soil	As (ind.)	kg	1000
Soil	Atrazine (agr.)	kg	21
Soil	Azinphos-methyl (agr.)	kg	39
Soil	Bentazon (agr.)	kg	15
Soil	benzene (ind.)	kg	1600
Soil	benzylchloride (ind.)	kg	490
Soil	Carbendazim (agr.)	kg	140
Soil	Cd (agr.)	kg	20000
Soil	Cd (ind.)	kg	67
Soil	Cr (III) (ind.)	kg	300
Soil	Cr (VI) (ind.)	kg	500
Soil	Cu (ind.)	kg	1.3
Soil	di(2-ethylhexyl)phthalate(ind)	kg	0.0052
Soil	dibutylphthalate (ind.)	kg	0.013
Soil	dichloromethane (ind.)	kg	1.3
Soil	Dichlorvos (agr.)	kg	0.97
Soil	Dieldrin (agr.)	kg	7600
Soil	dioxin (TEQ) (ind.)	kg	10000000
Soil	Diuron (agr.)	kg	1300
Soil	DNOC (agr.)	kg	280
Soil	ethylene oxide (ind.)	kg	4600
Soil	formaldehyde (ind.)	kg	0.019
Soil	gamma-HCH (Lindane) (agr.)	kg	490
Soil	hexachlorobenzene (ind.)	kg	1300000
Soil	Hg (ind.)	kg	1100
Soil	Malathion (agr.)	kg	0.026
Soil	Mecoprop (agr.)	kg	740
Soil	Metamitron (agr.)	kg	6.5
Soil	Mevinfos (agr.)	kg	5.7
Soil	Ni (ind.)	kg	200
Soil	Pb (ind.)	kg	290
Soil	pentachlorophenol (ind.)	kg	0.039
Soil	propylene oxide (ind.)	kg	590
Soil	Simazine (agr.)	kg	210

Impact category	x Human toxicity	kg 1,4-DB eq	
Soil	styrene (ind.)	kg	0.018
Soil	tetrachloroethene (ind.)	kg	5.2
Soil	tetrachloromethane (ind.)	kg	220
Soil	Thiram (agr.)	kg	7.9
Soil	toluene (ind.)	kg	0.21
Soil	trichloroethene (ind.)	kg	32
Soil	trichloromethane (ind.)	kg	10
Soil	vinyl chloride (ind.)	kg	83
Soil	Zn (ind.)	kg	0.42
Soil	phenol (agr.)	kg	1.9
Soil	Bentazon (ind.)	kg	0.16
Water	Fentin chloride (sea)	kg	12
Water	dihexylphthalate	kg	14000
Soil	Zineb (ind.)	kg	0.1
Soil	Iprodione (ind.)	kg	0.0032
Water	Fentin acetate	kg	880
Soil	Metolachlor (ind.)	kg	0.11
Soil	diethylphthalate (agr.)	kg	0.057
Water	Aldicarb	kg	61
Soil	Fenitrothion (ind.)	kg	0.32
Air	DDT	kg	110
Water	carbon disulfide	kg	2.4
Water	Dichlorvos (sea)	kg	0.0023
Soil	1,3,5-trichlorobenzene (agr.)	kg	69
Soil	2-chlorophenol (agr.)	kg	8.3
Air	Propachlor	kg	12
Soil	Captan (agr.)	kg	0.097
Water	toluene (sea)	kg	0.039
Soil	2,4-dichlorophenol (ind.)	kg	1.9
Air	Parathion-ethyl	kg	3.3
Soil	styrene (agr.)	kg	0.48
Soil	barium (agr.)	kg	360
Water	m-xylene	kg	0.34
Water	Parathion-methyl	kg	100
Water	Trichlorfon	kg	0.37
Soil	Demeton (agr.)	kg	5700
Water	Cypermethrin	kg	5.5
Soil	ethylene (ind.)	kg	0.62
Water	1,4-dichlorobenzene	kg	1.1
Water	Acephate (sea)	kg	0.00051
Soil	1,3-dichlorobenzene (agr.)	kg	250
Soil	benzylchloride (agr.)	kg	5500
Soil	Oxamyl (agr.)	kg	10
Air	tributyltinoxide	kg	7500
Water	Pirimicarb (sea)	kg	0.0013
Water	Methomyl	kg	3.3
Water	dimethylphthalate	kg	7.2
Air	hexachloro-1,3-butadiene	kg	79000
Soil	As (agr.)	kg	32000
Soil	2,3,4,6-tetrachlorophenol (ind.)	kg	1.6
Water	Dinoseb (sea)	kg	0.63
Water	Folpet (sea)	kg	0.31
Soil	Metazachlor (agr.)	kg	49
Water	o-xylene (sea)	kg	0.026
Soil	anilazine (agr.)	kg	0.08
Soil	diisodecylphthalate (agr.)	kg	110
Soil	Dichlorvos (ind.)	kg	0.036
Water	Anilazine	kg	0.24
Water	Metobromuron	kg	8
Soil	Azinphos-ethyl (agr.)	kg	760
Water	Aldicarb (sea)	kg	0.24
Soil	carbon disulfide (ind.)	kg	2.2
Water	Oxamyl	kg	0.36
Water	Chlorpyriphos (sea)	kg	0.038
Soil	Metazachlor (ind.)	kg	0.16
Air	2-chlorophenol	kg	22
Water	Fenthion (sea)	kg	0.46
Air	Tolclophos-methyl	kg	0.06
Soil	pentachlorobenzene (ind.)	kg	140
Air	dihexylphthalate	kg	7000
Soil	MCPA (agr.)	kg	100
Soil	Chlorpyriphos (ind.)	kg	0.14
Soil	Parathion-ethyl (agr.)	kg	2.9
Soil	Cyanazine (ind.)	kg	0.35
Soil	Glyphosate (ind.)	kg	0.00065
Air	Carbaryl	kg	3.2
Soil	Pyrazophos (agr.)	kg	51
Water	hexachloro-1,3-butadiene	kg	80000
Soil	benzene (agr.)	kg	15000
Water	Chlordane (sea)	kg	1200
Water	Dimethoate (sea)	kg	0.0033
Water	Iprodione (sea)	kg	0.00012
Soil	dioxin (TEQ) (agr.)	kg	1300000000
Water	Carbaryl	kg	4.7
Soil	Desmetryn (agr.)	kg	650
Water	Bifenthrin (sea)	kg	0.75
Water	1,2,3,4-tetrachlorobenzene	kg	160
Water	Heptenophos (sea)	kg	0.0023
Soil	Dinoseb (ind.)	kg	97
Air	cypermethrin	kg	170
Soil	Heptenophos (ind.)	kg	0.02
Air	1-chloro-4-nitrobenzene	kg	1200
Soil	Malathion (ind.)	kg	0.00095
Soil	para-xylene (agr.)	kg	3
Water	1,4-dichlorobenzene (sea)	kg	0.47
Soil	acrolein (ind.)	kg	17
Air	Glyphosate	kg	0.0031
Water	Glyphosate	kg	0.066
Water	2,3,4,6-tetrachlorophenol	kg	0.26

Impact category	x Human toxicity (sea)	kg 1,4-DB eq	
Water	1,2,3-trichlorobenzene (sea)	kg	62
Soil	Chlorothalonil (ind.)	kg	1
Soil	Acephate (ind.)	kg	0.31
Soil	Methabenzthiazuron (ind.)	kg	0.36
Water	1,2-dichlorobenzene (sea)	kg	4.1
Soil	naphtalene (ind.)	kg	1.6
Water	2,4-D (sea)	kg	0.000067
Soil	Dinoseb (agr.)	kg	560
Soil	diisooctylphthalate (ind.)	kg	0.052
Soil	methylbromide (ind.)	kg	260
Water	Demeton	kg	720
Soil	Aldicarb (agr.)	kg	510
Soil	Endrin (agr.)	kg	8400
Air	Heptenophos	kg	23
Soil	Folpet (ind.)	kg	1.5
Air	Chlorpropham	kg	0.34
Water	2,4-dichlorophenol (sea)	kg	0.065
Soil	Diuron (ind.)	kg	7.2
Soil	Acephate (agr.)	kg	22
Soil	1,1,1-trichloroethane (agr.)	kg	16
Soil	chlorobenzene (agr.)	kg	7.1
Water	Triazophos	kg	320
Soil	dihexylphthalate (ind.)	kg	14
Water	Mo (sea)	kg	6800
Water	Sb (sea)	kg	8600
Soil	Fenthion (agr.)	kg	30
Water	Oxamyl (sea)	kg	0.000014
Water	Fenthion	kg	93
Water	ethene (sea)	kg	0.047
Water	Bentazon (sea)	kg	0.0022
Water	Fentin hydroxide (sea)	kg	4.1
Air	1,2,4,5-tetrachlorobenzene	kg	35
Water	Cu (sea)	kg	5.9
Soil	Mevinfos (ind.)	kg	0.055
Water	1,2,3,5-tetrachlorobenzene	kg	92
Water	Iprodione	kg	0.18
Water	Ethoprophos	kg	1800
Water	diisodecylphthalate (sea)	kg	3.2
Water	methyl-mercury	kg	15000
Air	dinoseb	kg	3600
Soil	2,4,5-T (ind.)	kg	0.18
Soil	Methomyl (ind.)	kg	0.69
Soil	Triazophos (agr.)	kg	1200
Water	diisodecylphthalate	kg	19
Soil	Cyromazine (agr.)	kg	280
Soil	Thiram (ind.)	kg	0.25
Water	Co (sea)	kg	60
Soil	ethylbenzene (ind.)	kg	0.5
Water	propylene oxide (sea)	kg	16
Soil	vanadium (agr.)	kg	19000
Water	Dichlorprop (sea)	kg	0.097
Water	thallium	kg	230000
Water	Chlorothalonil (sea)	kg	0.45
Water	Triazophos (sea)	kg	1.6
Air	3-chloroaniline	kg	17000
Soil	bifenthrin (ind.)	kg	0.3
Water	tetrachloromethane (sea)	kg	170
Water	4-chloroaniline (sea)	kg	4
Water	Parathion-ethyl	kg	31
Air	Chlorpyriphos	kg	21
Soil	ethylene (agr.)	kg	0.78
Soil	pentachloronitrobenzene (agr.)	kg	72
Soil	Folpet (agr.)	kg	13
Soil	anthracene (ind.)	kg	0.02
Air	Parathion-methyl	kg	53
Air	Lindane	kg	610
Water	trichloroethene (sea)	kg	14
Water	Phoxim (sea)	kg	0.29
Soil	Heptachlor (agr.)	kg	670
Soil	Dimethoate (agr.)	kg	320
Water	Glyphosate (sea)	kg	0.000015
Water	3,4-dichloroaniline (sea)	kg	1.5
Soil	Metolachlor (agr.)	kg	11
Soil	Dichlorprop (ind.)	kg	0.26
Soil	1,4-dichlorobenzene (ind.)	kg	0.74
Soil	Chlordane (agr.)	kg	2800
Water	Linuron (sea)	kg	0.65
Air	Metobromuron	kg	55
Soil	toluene (agr.)	kg	0.35
Water	styrene (sea)	kg	0.01
Air	Oxamyl	kg	1.4
Water	Chloridazon (sea)	kg	0.0021
Soil	Dichlorprop (agr.)	kg	4.5
Water	Ethoprophos (sea)	kg	13
Soil	phenol (ind.)	kg	0.006
Soil	Parathion-methyl (ind.)	kg	1.7
Air	Chlordane	kg	6700
Soil	Fentin acetate (agr.)	kg	72
Water	Metamitron (sea)	kg	0.000032
Water	Methabenzthiazuron	kg	2.6
Air	Permethrin	kg	0.85
Soil	Pyrazophos (ind.)	kg	1.2
Soil	4-chloroaniline (ind.)	kg	510
Air	4-chloroaniline	kg	260
Soil	thallium (agr.)	kg	2000000
Air	Acephate	kg	3.1
Water	naphtalene	kg	5.6
Air	Metolachlor	kg	2.6

Impact category	x Human toxicity	kg 1,4-DB eq	
Water	benzylchloride (sea)	kg	55
Soil	Ethoprophos (agr.)	kg	5700
Air	Deltamethrin	kg	1.6
Soil	anilazine (ind.)	kg	0.0003
Soil	Dinoterb (ind.)	kg	0.12
Soil	Coumaphos (agr.)	kg	11000
Water	Permethrin (sea)	kg	0.26
Air	anilazine	kg	0.072
Water	1,2-dichloroethane (sea)	kg	5.5
Soil	tetrachloromethane (agr.)	kg	220
Soil	tributyltinoxide (ind.)	kg	43
Water	Pb (sea)	kg	79
Water	dioxins (TEQ) (sea)	kg	420000000
Water	naphtalene (sea)	kg	0.19
Soil	Propoxur (ind.)	kg	0.27
Soil	dibutylphthalate (agr.)	kg	1.3
Air	Ethoprophos	kg	1100
Soil	diethylphthalate (ind.)	kg	0.0033
Soil	Pirimicarb (ind.)	kg	0.29
Water	Metazachlor (sea)	kg	0.0024
Air	Dichlorprop	kg	1.1
Water	3-chloroaniline (sea)	kg	2.1
Water	p-xylene	kg	0.35
Water	butylbenzylphthalate (sea)	kg	0.00085
Water	V (sea)	kg	6200
Water	Chlordane	kg	740
Water	Cd (sea)	kg	100
Soil	acrylonitrile (agr.)	kg	490000
Soil	Co (agr.)	kg	2400
Soil	butylbenzylphthalate (ind.)	kg	0.0018
Water	Thiram (sea)	kg	0.00066
Soil	Endrin (ind.)	kg	750
Water	methyl-mercury (sea)	kg	88000
Soil	Carbendazim (ind.)	kg	0.43
Air	2,4,5-trichlorophenol	kg	8.3
Water	ethylene oxide (sea)	kg	540
Soil	Propoxur (agr.)	kg	270
Water	DDT (sea)	kg	34
Water	Deltamethrin (sea)	kg	0.033
Water	benzene (sea)	kg	210
Soil	antimony (agr.)	kg	8900
Soil	diisooctylphthalate (agr.)	kg	32
Soil	Dieldrin (ind.)	kg	1500
Water	dioctylphthalate (sea)	kg	1.3
Water	Chlorpropham (sea)	kg	0.0043
Air	Pyrazophos	kg	25
Air	Triazophos	kg	210
Air	Oxydemethon-methyl	kg	120
Soil	dioctylphthalate (agr.)	kg	8.6
Soil	Oxamyl (ind.)	kg	0.068
Soil	pentachlorophenol (agr.)	kg	0.15
Soil	Linuron (ind.)	kg	9.4
Soil	Chloridazon (ind.)	kg	0.02
Water	Endosulfan (sea)	kg	0.042
Soil	propylene oxide (agr.)	kg	220000
Soil	Atrazine (ind.)	kg	0.88
Soil	Pb (agr.)	kg	3300
Soil	2,4-dichlorophenol (agr.)	kg	740
Water	Chlorfenvinphos (sea)	kg	3.8
Soil	Metamitron (ind.)	kg	0.012
Water	hexachlorobenzene (sea)	kg	3400000
Water	o-xylene	kg	0.42
Water	Fenitrothion (sea)	kg	0.09
Water	Coumaphos (sea)	kg	220
Water	Ni (sea)	kg	750
Soil	PAH (carcinogenic) (agr.)	kg	71000
Soil	Cyanazine (agr.)	kg	24
Soil	Zineb (agr.)	kg	20
Soil	ethylbenzene (agr.)	kg	0.75
Soil	hexachloro-1,3-butadiene (agr.)	kg	30000
Soil	Azinphos-methyl (ind.)	kg	0.099
Air	butylbenzylphthalate	kg	10
Water	Tri-allate (sea)	kg	1.2
Water	pentachlorophenol (sea)	kg	0.14
Water	Mecoprop (sea)	kg	0.84
Soil	dimethylphthalate (ind.)	kg	0.27
Water	1,2,3,4-tetrachlorobenzene (sea)	kg	30
Water	Methabenzthiazuron (sea)	kg	0.0082
Soil	Tolclophos-methyl (agr.)	kg	11
Soil	Aldicarb (ind.)	kg	13
Air	pentachloronitrobenzene	kg	190
Soil	hexachloro-1,3-butadiene (ind.)	kg	35000
Soil	hexachlorobenzene (agr.)	kg	33000000
Soil	vanadium (ind.)	kg	1700
Soil	bifenthrin (agr.)	kg	29
Soil	trichloroethene (agr.)	kg	32
Soil	DDT (agr.)	kg	270
Water	Captafol (sea)	kg	9.7
Water	Methomyl (sea)	kg	0.0014
Soil	Deltamethrin (ind.)	kg	0.03
Water	phthalic anhydride	kg	0.00011
Soil	1,2-dichloroethane (agr.)	kg	1300
Water	diethylphthalate	kg	0.14
Soil	Cu (agr.)	kg	94
Water	dimethylphthalate (sea)	kg	0.0084
Soil	Benomyl (ind.)	kg	0.0011
Water	Permethrin	kg	23

Impact category	x Human toxicity	kg 1,4-DB eq	
Soil	1,2,3,4-tetrachlorobenzene (agr.)	kg	80
Air	diazinon	kg	59
Water	Folpet	kg	8.6
Soil	Cr (III) (agr.)	kg	5100
Air	2,3,4,6-tetrachlorophenol	kg	290
Soil	Chloridazon (agr.)	kg	2.2
Soil	Fentin hydroxide (agr.)	kg	88
Water	Parathion-methyl (sea)	kg	0.54
Air	methomyl	kg	6.2
Water	Propoxur	kg	1.3
Soil	meta-xylene (ind.)	kg	0.019
Water	Deltamethrin	kg	2.8
Soil	Dimethoate (ind.)	kg	3
Water	1-chloro-4-nitrobenzene (sea)	kg	220
Water	methylbromide	kg	300
Water	PAH (sea)	kg	29000
Soil	Oxydemethon-methyl (ind.)	kg	3.8
Soil	Chlorothalonil (agr.)	kg	0.94
Water	1,2,4-trichlorobenzene (sea)	kg	56
Water	1,3-dichlorobenzene	kg	74
Soil	3,4-dichloroaniline (ind.)	kg	31
Water	thallium (sea)	kg	290000
Water	Dinoseb	kg	160
Air	anthracene	kg	0.52
Water	Mevinfos (sea)	kg	0.0018
Soil	Triazophos (ind.)	kg	37
Water	Isoproturon	kg	13
Water	tributyltinoxide (sea)	kg	55
Water	1,3-dichlorobenzene (sea)	kg	30
Water	HF (sea)	kg	3600
Water	Azinphos-methyl (sea)	kg	0.0057
Air	Bifenthrin	kg	19
Air	diethylphthalate	kg	0.32
Soil	Aldrin (ind.)	kg	160
Water	diethylphthalate (sea)	kg	0.00057
Water	2,4,5-T	kg	1.9
Water	Hg (sea)	kg	8200
Water	Cypermethrin (sea)	kg	0.026
Soil	trichloromethane (agr.)	kg	14
Water	Trichlorfon (sea)	kg	0.000031
Soil	Mecoprop (ind.)	kg	42
Air	Iprodione	kg	0.28
Water	Chlorpyriphos	kg	44
Soil	Benomyl (agr.)	kg	0.43
Soil	Chlordane (ind.)	kg	27
Soil	3-chloroaniline (agr.)	kg	30000
Soil	Ni (agr.)	kg	2700
Soil	Fenthion (ind.)	kg	1.5
Water	Lindane	kg	830
Soil	1,2,3-trichlorobenzene (agr.)	kg	56
Soil	tin (agr.)	kg	13
Water	Captafol	kg	500
Water	Cr (VI) (sea)	kg	17
Water	Chlorfenvinphos	kg	810
Air	tri-allate	kg	9.7
Soil	Trichlorfon (ind.)	kg	0.02
Air	pentachlorobenzene	kg	410
Air	2,4,5-T	kg	0.89
Soil	selenium (ind.)	kg	28000
Air	1,2,3,5-tetrachlorobenzene	kg	46
Water	dibutylphthalate (sea)	kg	0.003
Water	Cr (III) (sea)	kg	10
Air	chlorobenzene	kg	9.2
Soil	Fentin chloride (agr.)	kg	130
Soil	Simazine (ind.)	kg	2.2
Soil	1,2,3,5-tetrachlorobenzene (ind.)	kg	14
Soil	methylbromide (agr.)	kg	260
Water	Parathion-ethyl (sea)	kg	0.18
Soil	Pirimicarb (agr.)	kg	26
Water	Pyrazophos	kg	53
Soil	1,2,4-trichlorobenzene (agr.)	kg	42
Water	trichloromethane (sea)	kg	6
Air	Captafol	kg	87
Soil	Propachlor (ind.)	kg	0.14
Air	Endrin	kg	1200
Soil	Fentin chloride (ind.)	kg	13
Soil	thallium (ind.)	kg	120000
Air	Fentin hydroxide	kg	850
Soil	1,2,3,5-tetrachlorobenzene (agr.)	kg	180
Air	Desmetryn	kg	95
Soil	Iprodione (agr.)	kg	1.8
Air	Pirimicarb	kg	3.4
Air	MCPA	kg	15
Soil	Tri-allate (agr.)	kg	5.8
Soil	dioctylphthalate (ind.)	kg	0.0088
Water	1-chloro-4-nitrobenzene	kg	1700
Water	vinyl chloride (sea)	kg	43
Water	Fentin hydroxide	kg	870
Soil	gamma-HCH (Lindane) (ind.)	kg	52
Soil	butylbenzylphthalate (agr.)	kg	0.31
Air	coumaphos	kg	780
Soil	Isoproturon (ind.)	kg	2.8
Soil	Captafol (agr.)	kg	960
Water	phenol (sea)	kg	0.00008
Water	Diazinon (sea)	kg	0.27

Impact category	x Human toxicity	kg 1,4-DB eq	
Water	diisooctylphthalate	kg	18
Soil	antimony (ind.)	kg	2600
Water	Captan (sea)	kg	0.0000054
Water	Cyromazine (sea)	kg	0.0026
Air	3,4-dichloroaniline	kg	220
Water	Metobromuron (sea)	kg	0.076
Soil	Trichlorfon (agr.)	kg	33
Soil	Chlorpyriphos (agr.)	kg	14
Soil	Desmetryn (ind.)	kg	2.9
Water	pentachloronitrobenzene (sea)	kg	46
Soil	2,4,5-trichlorophenol (ind.)	kg	2.9
Water	Anilazine (sea)	kg	0.00082
Water	1,2,3,5-tetrachlorobenzene (sea)	kg	25
Air	dioctylphthalate	kg	19
Air	1,2,3,4-tetrachlorobenzene	kg	50
Water	Trifluralin (sea)	kg	6
Soil	1,2-dichlorobenzene (agr.)	kg	7.3
Soil	Diazinon (agr.)	kg	120
Soil	methyl-mercury (agr.)	kg	20000
Air	1,2-dichlorobenzene	kg	9.1
Water	Be (sea)	kg	16000
Soil	di(2-ethylhexyl)phthalate (agr.)	kg	1.8
Air	Metazachlor	kg	6.8
Soil	2-chlorophenol (ind.)	kg	1.4
Water	HF	kg	3600
Water	Tolclophos-methyl (sea)	kg	0.065
Soil	Chlorpropham (ind.)	kg	0.081
Soil	Co (ind.)	kg	59
Water	Metazachlor	kg	1.7
Soil	Fentin acetate (ind.)	kg	9.2
Water	Cyromazine	kg	5.4
Water	1,3,5-trichlorobenzene (sea)	kg	54
Soil	Dinoterb (agr.)	kg	0.36
Air	Disulfothon	kg	290
Water	phthalic anhydride (sea)	kg	0.0000001
Soil	methyl-mercury (ind.)	kg	11000
Soil	Tolclophos-methyl (ind.)	kg	0.04
Water	Desmetryn	kg	50
Water	Chlorothalonil	kg	6.7
Water	Pirimicarb	kg	1.7
Water	formaldehyde (sea)	kg	0.000028
Soil	Linuron (agr.)	kg	170
Soil	1-chloro-4-nitrobenzene (agr.)	kg	22000
Water	2,4,5-trichlorophenol	kg	45
Soil	tributyltinoxide (agr.)	kg	290
Water	Azinphos-ethyl (sea)	kg	1.6
Water	Chloridazon	kg	0.14
Water	Phoxim	kg	12
Air	Captan	kg	0.59
Soil	Phoxim (agr.)	kg	25
Water	Tri-allate	kg	83
Water	2,4,5-T (sea)	kg	0.0054
Soil	beryllium (ind.)	kg	7000
Soil	Carbaryl (agr.)	kg	21
Soil	Captan (ind.)	kg	0.00011
Soil	beryllium (agr.)	kg	13000
Soil	meta-xylene (agr.)	kg	3.8
Water	Endrin (sea)	kg	1600
Water	Metolachlor	kg	0.55
Water	Aldrin (sea)	kg	780
Soil	tetrachloroethene (agr.)	kg	6.4
Water	Se (sea)	kg	63000
Air	Chlorothalonil	kg	8.4
Soil	Propachlor (agr.)	kg	15
Air	cyromazine	kg	38
Soil	Parathion-ethyl (ind.)	kg	0.11
Water	ethene	kg	0.65
Water	1,1,1-trichloroethane (sea)	kg	9.6
Soil	ortho-xylene (agr.)	kg	5
Air	Propoxur	kg	37
Air	Fenitrothion	kg	5.9
Water	di(2-ethylhexyl)phthalate (sea)	kg	0.04
Water	Carbendazim (sea)	kg	0.002
Soil	Heptenophos (agr.)	kg	3.4
Air	Linuron	kg	14
Soil	Endosulfan (ind.)	kg	0.016
Soil	Coumaphos (ind.)	kg	1600
Soil	Phtalic anhydride (ind.)	kg	0.00000066
Air	Fentin chloride	kg	840
Water	acrylonitrile (sea)	kg	51
Water	Coumaphos	kg	10000
Soil	Cr (VI) (agr.)	kg	8500
Water	hexachloro-1,3-butadiene (sea)	kg	39000
Soil	Trifluarin (ind.)	kg	0.68
Soil	DDT (ind.)	kg	1.8
Water	Zineb (sea)	kg	0.00082
Water	Bifenthrin	kg	98
Water	Simazine (sea)	kg	0.016
Air	Aldicarb	kg	72
Soil	Cypermethrin (agr.)	kg	5200
Water	3,4-dichloroaniline	kg	130
Water	Disulfothon (sea)	kg	1.5
Soil	barium (ind.)	kg	320
Air	cyanazine	kg	3.5

Impact category	x Human toxicity	kg 1,4-DB eq	
Soil	Tri-allate (ind.)	kg	0.36
Soil	1,2,3,4-tetrachlorobenzene (ind.)	kg	5.2
Water	Metolachlor (sea)	kg	0.00085
Soil	Phtalic anhydride (agr.)	kg	0.01
Water	Linuron	kg	110
Air	Chlorfenvinphos	kg	270
Water	Acephate	kg	2.1
Water	Tolclophos-methyl	kg	1
Soil	1,2,4,5-tetrachlorobenzene (agr.)	kg	84
Water	m-xylene (sea)	kg	0.01
Soil	1,3-dichlorobenzene (ind.)	kg	50
Water	Endosulfan	kg	17
Soil	Demeton (ind.)	kg	89
Air	Benomyl	kg	0.021
Soil	DNOC (ind.)	kg	2.8
Air	Chloridazon	kg	0.013
Water	Carbofuran (sea)	kg	0.21
Soil	3-chloroaniline (ind.)	kg	460
Soil	Zn (agr.)	kg	64
Air	Folpet	kg	2
Soil	Chlorfenvinphos (agr.)	kg	1200
Water	1,2,4,5-tetrachlorobenzene	kg	180
Water	2-chlorophenol (sea)	kg	0.35
Water	Benomyl (sea)	kg	0.00024
Air	Azinphos-ethyl	kg	200
Soil	Methabenzthiazuron (agr.)	kg	51
Air	1,3-dichlorobenzene	kg	62
Water	cyanazine	kg	6
Water	2-chlorophenol	kg	70
Soil	Endosulfan (agr.)	kg	0.26
Air	diisooctylphthalate	kg	310
Soil	Azinphos-ethyl (ind.)	kg	6.9
Water	Zn (sea)	kg	3.2
Air	methyl-mercury	kg	58000
Soil	Diazinon (ind.)	kg	3.2
Water	anthracene (sea)	kg	0.16
Water	acrolein	kg	59
Water	anthracene	kg	2.1
Air	Phoxim	kg	0.97
Air	1,4-dichlorobenzene	kg	1
Soil	Chlorfenvinphos (ind.)	kg	44
Soil	Trifluarin (agr.)	kg	120
Soil	hydrogen fluoride (agr.)	kg	1800
Water	Ba (sea)	kg	800
Soil	Permethrin (ind.)	kg	0.021
Soil	Fentin hydroxide (ind.)	kg	8.5
Air	zineb	kg	4.8
Soil	2,3,4,6-tetrachlorophenol (agr.)	kg	31
Water	Demeton (sea)	kg	0.3
Water	MCPA	kg	15
Water	2,3,4,6-tetrachlorophenol	kg	35
Soil	3,4-dichloroaniline (agr.)	kg	1700
Water	DDT	kg	37
Soil	selenium (agr.)	kg	29000
Water	Malathion (sea)	kg	0.00084
Soil	2,4-D (ind.)	kg	0.72
Soil	PAH (carcinogenic) (ind.)	kg	2700
Water	Heptachlor	kg	3400
Soil	Cyromazine (ind.)	kg	1.3
Water	chlorobenzene	kg	9.1
Soil	Carbofuran (ind.)	kg	8
Water	Heptachlor (sea)	kg	43
Water	Oxydemethon-methyl	kg	74
Water	Atrazine (sea)	kg	0.018
Soil	naphtalene (agr.)	kg	4.8
Soil	pentachlorobenzene (agr.)	kg	4500
Water	Sn (sea)	kg	0.11
Water	Propachlor	kg	1.6
Water	1,3-butadiene (sea)	kg	450
Water	2,4,5-trichlorophenol (sea)	kg	0.61
Air	dinoterb	kg	170
Water	pentachlorobenzene (sea)	kg	410
Water	DNOC (sea)	kg	0.0015
Water	Propachlor (sea)	kg	0.0026
Soil	Carbofuran (agr.)	kg	1400
Water	Fentin chloride	kg	860
Water	diisooctylphthalate (sea)	kg	9.7
Water	Fenitrothion	kg	22
Soil	Disulfoton (ind.)	kg	2
Soil	Fenitrothion (agr.)	kg	12
Soil	Captafol (ind.)	kg	79
Air	2,4-dichlorophenol	kg	95
Soil	Carbaryl (ind.)	kg	0.15
Air	diisodecylphthalate	kg	46
Soil	anthracene (agr.)	kg	0.51
Soil	1,2-dichlorobenzene (ind.)	kg	6.9
Water	2,4,6-trichlorophenol (sea)	kg	47
Soil	Permethrin (agr.)	kg	11
Soil	ethylene oxide (agr.)	kg	110000
Water	MCPA (sea)	kg	0.037
Water	pentachloronitrobenzene	kg	91
Air	Isoproturon	kg	130
Water	Disulfothon	kg	340
Soil	dichloromethane (agr.)	kg	2.4
Soil	diisodecylphthalate (ind.)	kg	0.038
Water	ethyl benzene (sea)	kg	0.07
Water	Propoxur (sea)	kg	0.00039

Impact category	x Human toxicity	kg 1,4-DB eq	
Water	Diuron (sea)	kg	0.19
Soil	Parathion-methyl (agr.)	kg	24
Water	Dichlorprop	kg	24
Water	dioctylphthalate	kg	6.3
Soil	Isoproturon (agr.)	kg	960
Soil	formaldehyde (agr.)	kg	2.3
Soil	Methomyl (agr.)	kg	43
Water	Zineb	kg	1.7
Water	Heptenophos	kg	1.3
Soil	hydrogen fluoride (ind.)	kg	1800
Soil	dihexylphthalate (agr.)	kg	1200
Soil	2,4,5-T (agr.)	kg	5.8
Water	pentachlorobenzene	kg	1200
Soil	chlorobenzene (ind.)	kg	6.8
Soil	ortho-xylene (ind.)	kg	0.076
Soil	Heptachlor (ind.)	kg	4.4
Soil	Glyphosate (agr.)	kg	0.015
Water	Dimethoate	kg	18
Water	As (sea)	kg	2400
Water	3-chloroaniline	kg	3500
Soil	1,2,4,5-tetrachlorobenzene (ind.)	kg	5.4
Water	p-xylene (sea)	kg	0.013
Water	acrolein (sea)	kg	0.8
Water	Benomyl	kg	0.14
Soil	tin (ind.)	kg	0.52
Soil	para-xylene (ind.)	kg	0.025
Soil	Oxydemethon-methyl (agr.)	kg	610
Soil	1,4-dichlorobenzene (agr.)	kg	2.9
Soil	dimethylphthalate (agr.)	kg	28
Water	tetrachloroethene (sea)	kg	2.8
Water	Carbaryl (sea)	kg	0.0019
Air	dimethylphthalate	kg	210
Water	Desmetryn (sea)	kg	0.12
Air	Demeton	kg	71
Soil	carbon disulfide (agr.)	kg	3.6
Soil	Ethoprophos (ind.)	kg	380
Water	Azinphos-ethyl	kg	460
Water	chlorobenzene (sea)	kg	5.2
Soil	1,1,1-trichloroethane (ind.)	kg	16
Soil	Chlorpropham (agr.)	kg	2.1
Water	dichloromethane (sea)	kg	0.3
Air	Carbofuran	kg	200
Air	dimethoate	kg	44
Air	Endosulfan	kg	6.7
Soil	1-chloro-4-nitrobenzene (ind.)	kg	460
Soil	4-chloroaniline (agr.)	kg	35000
Water	Isoproturon (sea)	kg	0.029
Water	Dinoterb	kg	2.5
Soil	2,4,5-trichlorophenol (agr.)	kg	5.3
Soil	1,3-butadiene (agr.)	kg	3100
Soil	Metobromuron (agr.)	kg	410
Water	1,1,1-trichloroethane	kg	16
Soil	pentachloronitrobenzene (ind.)	kg	4.3
Water	Lindane (sea)	kg	6.1
Water	Chlorpropham	kg	1
Water	tributyltinoxide	kg	3400
Soil	Mo (ind.)	kg	3100
Water	Diazinon	kg	66
Water	Captan	kg	0.0053
Soil	Hg (agr.)	kg	5900
Water	cyanazine (sea)	kg	0.0096
Soil	vinyl chloride (agr.)	kg	520
Soil	Cypermethrin (ind.)	kg	1.8
Water	Fentin acetate (sea)	kg	4.1
Water	dihexylphthalate (sea)	kg	370
Water	methylbromide (sea)	kg	25
Water	1,2-dichlorobenzene	kg	8.9
Water	1,2,4,5-tetrachlorobenzene (sea)	kg	30
Air	Heptachlor	kg	40
Soil	Phoxim (ind.)	kg	0.38
Water	Dieldrin (sea)	kg	5500
Soil	Metobromuron (ind.)	kg	1.9
Water	Pyrazophos (sea)	kg	0.23
Soil	Deltamethrin (agr.)	kg	0.16
Soil	Mo (agr.)	kg	6200
Water	Endrin	kg	6000
Air	Trichlorfon	kg	4.4
Soil	2,4,6-trichlorophenol (agr.)	kg	1800
Water	Carbofuran	kg	56
Air	Fenthion	kg	63
Water	4-chloroaniline	kg	2900
Soil	acrolein (agr.)	kg	230
Soil	MCPA (ind.)	kg	0.97
Water	carbon disulfide (sea)	kg	0.48
Water	Dinoterb (sea)	kg	0.0029
Water	Oxydemethon-methyl (sea)	kg	0.01
Water	2,4-dichlorophenol	kg	16
Soil	Disulfoton (agr.)	kg	170
Air	dust (PM10) stationary	kg	0.82
Air	dust (PM10) mobile	kg	0.82
Water	butylbenzylphthalate	kg	0.086

Table B1.5 Freshwater Aquatic Ecotoxicity

Impact category	x Fresh water aquatic ecotox.	kg 1,4-DB eq	
Air	1,1,1-trichloroethane	kg	0.00012
Air	1,2,3-trichlorobenzene	kg	0.0085
Air	1,2,4-trichlorobenzene	kg	0.0099
Air	1,2-dichloroethane	kg	0.00012
Air	1,3,5-trichlorobenzene	kg	0.016
Air	1,3-butadiene	kg	0.00000033
Air	2,4,6-trichlorophenol	kg	5.9
Air	2,4-D	kg	39
Air	acrolein	kg	520
Air	acrylonitrile	kg	0.41
Air	Aldrin	kg	2.7
Air	As	kg	50
Air	Atrazine	kg	360
Air	Azinphos-methyl	kg	420
Air	Ba	kg	43
Air	Be	kg	17000
Air	Bentazon	kg	5.6
Air	benzene	kg	0.000084
Air	benzo(a)anthracene	kg	42
Air	benzo(a)pyrene	kg	88
Air	benzylchloride	kg	0.76
Air	Carbendazim	kg	3000
Air	Cd	kg	290
Air	cobalt	kg	640
Air	Cr (III)	kg	1.9
Air	Cr (VI)	kg	7.7
Air	CS2	kg	0.033
Air	Cu	kg	220
Air	di(2-ethylhexyl)phthalate	kg	0.35
Air	dibutylphthalate	kg	0.56
Air	dichloromethane	kg	0.000033
Air	Dichlorvos	kg	510
Air	Dieldrin	kg	200
Air	dioxin (TEQ)	kg	2100000
Air	Diuron	kg	530
Air	DNOC	kg	3.4
Air	ethene	kg	1.4E-11
Air	ethylbenzene	kg	0.00013
Air	ethylene oxide	kg	0.099
Air	Fentin-acetate	kg	4300
Air	fluoranthene	kg	18
Air	formaldehyde	kg	8.3
Air	heavy metals	kg	21.43
Air	hexachlorobenzene	kg	1.3
Air	HF	kg	4.6
Air	Hg	kg	320
Air	m-xylene	kg	0.000044
Air	Malathion	kg	1800
Air	Mecoprop	kg	37
Air	Metabenzthiazuron	kg	70
Air	metals	kg	21.43
Air	Metamitron	kg	0.93
Air	methyl bromide	kg	0.033
Air	Mevinfos	kg	9300
Air	Mo	kg	97
Air	naphthalene	kg	0.5
Air	Ni	kg	630
Air	o-xylene	kg	0.000093
Air	p-xylene	kg	0.000061
Air	PAH's	kg	170
Air	Pb	kg	2.4
Air	pentachlorophenol	kg	11
Air	phenol	kg	1.5
Air	phthalic acid anhydride	kg	0.0082
Air	propyleneoxide	kg	0.037
Air	Sb	kg	3.7
Air	Se	kg	550
Air	Simazine	kg	2100
Air	Sn	kg	2.5
Air	styrene	kg	0.000051
Air	tetrachloroethene	kg	0.00041
Air	tetrachloromethane	kg	0.00025
Air	Thiram	kg	2700
Air	Tl	kg	1600
Air	toluene	kg	0.00007
Air	trichloroethene	kg	0.000038
Air	trichloromethane	kg	0.000095
Air	Trifluralin	kg	9.9
Air	V	kg	1700
Air	vinyl chloride	kg	0.0000029
Air	Zn	kg	18
Water	1,2,3-trichlorobenzene	kg	4
Water	1,2,4-trichlorobenzene	kg	3.5
Water	1,2-dichloroethane	kg	0.023
Water	1,3,5-trichlorobenzene	kg	5
Water	1,3-butadiene	kg	3
Water	2,4,6-trichlorophenol	kg	290
Water	2,4-D	kg	400
Water	acrylonitrile	kg	79
Water	Aldrin	kg	12000
Water	As	kg	210
Water	Atrazine	kg	5000
Water	Azinphos-methyl	kg	52000
Water	Ba	kg	230
Water	Be	kg	91000
Water	Bentazon	kg	51

Impact category	x Fresh water aquatic ecotox.	kg 1,4-DB eq	
Water	benzene	kg	0.091
Water	benzo(a)anthracene	kg	110000
Water	benzo(a)pyrene	kg	250000
Water	benzylchloride	kg	200
Water	Carbendazim	kg	38000
Water	Cd	kg	1500
Water	Co	kg	3400
Water	Cr (III)	kg	6.9
Water	Cr (VI)	kg	28
Water	Cu	kg	1200
Water	di(2-ethylhexyl)phthalate	kg	79
Water	dibutylphthalate	kg	79
Water	dichloromethane	kg	0.012
Water	Dichlorvos	kg	120000
Water	Dieldrin	kg	79000
Water	dioxins (TEQ)	kg	170000000
Water	Diuron	kg	9400
Water	DNOC	kg	110
Water	ethyl benzene	kg	0.55
Water	ethylene oxide	kg	9.8
Water	fluoranthene	kg	13000
Water	formaldehyde	kg	280
Water	hexachlorobenzene	kg	150
Water	Hg	kg	1700
Water	Malathion	kg	210000
Water	Mecoprop	kg	380
Water	metallic ions	kg	3.659
Water	Metamitron	kg	23
Water	Mevinfos	kg	590000
Water	Mo	kg	480
Water	Ni	kg	3200
Water	PAH's	kg	28000
Water	Pb	kg	9.6
Water	pentachlorophenol	kg	710
Water	phenol	kg	240
Water	propylene oxide	kg	4
Water	Sb	kg	20
Water	Se	kg	2900
Water	Simazine	kg	27000
Water	Sn	kg	10
Water	styrene	kg	0.44
Water	tetrachloroethene	kg	0.7
Water	tetrachloromethane	kg	0.21
Water	Thiram	kg	98000
Water	toluene	kg	0.29
Water	trichloroethene	kg	0.097
Water	trichloromethane	kg	0.042
Water	Trifluralin	kg	27000
Water	V	kg	9000
Water	vinyl chloride	kg	0.028
Water	Zn	kg	92
Soil	1,2,3-trichlorobenzene (ind.)	kg	0.03
Soil	1,2,4-trichlorobenzene (ind.)	kg	0.032
Soil	1,2-dichloroethane (ind.)	kg	0.00075
Soil	1,3,5-trichlorobenzene (ind.)	kg	0.066
Soil	1,3-butadiene (ind.)	kg	0.000057
Soil	2,4,6-trichlorophenol (ind.)	kg	4.8
Soil	2,4-D (agr.)	kg	29
Soil	acrylonitrile (ind.)	kg	8.1
Soil	Aldrin (agr.)	kg	280
Soil	As (ind.)	kg	130
Soil	Atrazine (agr.)	kg	340
Soil	Azinphos-methyl (agr.)	kg	190
Soil	Bentazon (agr.)	kg	8.3
Soil	benzene (ind.)	kg	0.00072
Soil	benzo(a)pyrene (ind.)	kg	530
Soil	benzylchloride (ind.)	kg	3.2
Soil	Carbendazim (agr.)	kg	2000
Soil	Cd (agr.)	kg	780
Soil	Cd (ind.)	kg	780
Soil	Cr (III) (ind.)	kg	5.3
Soil	Cr (VI) (ind.)	kg	21
Soil	Cu (ind.)	kg	590
Soil	di(2-ethylhexyl)phthalate(ind)	kg	0.006
Soil	dibutylphthalate (ind.)	kg	0.31
Soil	dichloromethane (ind.)	kg	0.00016
Soil	Dichlorvos (agr.)	kg	74
Soil	Dieldrin (agr.)	kg	600
Soil	dioxin (TEQ) (ind.)	kg	490000
Soil	Diuron (agr.)	kg	350
Soil	DNOC (agr.)	kg	1.2
Soil	ethylene oxide (ind.)	kg	0.98
Soil	fluoranthene (ind.)	kg	76
Soil	formaldehyde (ind.)	kg	44
Soil	gamma-HCH (Lindane) (agr.)	kg	97
Soil	hexachlorobenzene (ind.)	kg	4.3
Soil	Hg (ind.)	kg	850
Soil	Malathion (agr.)	kg	160
Soil	Mecoprop (agr.)	kg	30
Soil	Metamitron (agr.)	kg	0.41
Soil	Mevinfos (agr.)	kg	350
Soil	Ni (ind.)	kg	1700
Soil	Pb (ind.)	kg	6.5
Soil	pentachlorophenol (ind.)	kg	1.3
Soil	propylene oxide (ind.)	kg	0.48
Soil	Simazine (agr.)	kg	2300
Soil	styrene (ind.)	kg	0.0026

Impact category	x Fresh water aquatic ecotox.	kg 1,4-DB eq	
Soil	tetrachloroethene (ind.)	kg	0.0022
Soil	tetrachloromethane (ind.)	kg	0.00056
Soil	Thiram (agr.)	kg	690
Soil	toluene (ind.)	kg	0.0011
Soil	trichloroethene (ind.)	kg	0.00046
Soil	trichloromethane (ind.)	kg	0.00047
Soil	vinyl chloride (ind.)	kg	0.000064
Soil	Zn (ind.)	kg	48
Soil	phenol (agr.)	kg	3.5
Soil	Bentazon (ind.)	kg	11
Water	Fentin chloride (sea)	kg	18
Water	dihexylphthalate	kg	110
Soil	Zineb (ind.)	kg	1400
Soil	Iprodione (ind.)	kg	1.9
Water	Fentin acetate	kg	270000
Soil	Metolachlor (ind.)	kg	5800
Soil	diethylphthalate (agr.)	kg	0.16
Water	Aldicarb	kg	440000
Soil	Fenitrothion (ind.)	kg	3000
Air	DDT	kg	320
Water	carbon disulfide	kg	110
Water	Dichlorvos (sea)	kg	0.011
Soil	1,3,5-trichlorobenzene (agr.)	kg	0.054
Soil	2-chlorophenol (agr.)	kg	7.9
Air	Propachlor	kg	20
Soil	Captan (agr.)	kg	0.4
Water	toluene (sea)	kg	0.0000083
Soil	2,4-dichlorophenol (ind.)	kg	9.2
Air	Parathion-ethyl	kg	2800
Soil	styrene (agr.)	kg	0.0015
Soil	barium (agr.)	kg	110
Water	m-xylene	kg	0.6
Water	Parathion-methyl	kg	290000
Water	Trichlorfon	kg	410000
Soil	Demeton (agr.)	kg	800
Water	Cypermethrin	kg	7900000
Soil	ethylene (ind.)	kg	1.1E-09
Water	1,4-dichlorobenzene	kg	1
Water	Acephate (sea)	kg	0.00000006
Soil	1,3-dichlorobenzene (agr.)	kg	0.018
Soil	benzylchloride (agr.)	kg	0.92
Soil	Oxamyl (agr.)	kg	30
Air	tributyltinoxide	kg	7700
Water	Pirimicarb (sea)	kg	0.00089
Water	Methomyl	kg	140000
Water	dimethylphthalate	kg	3.1
Air	hexachloro-1,3-butadiene	kg	46
Soil	As (agr.)	kg	130
Soil	2,3,4,6-tetrachlorophenol (ind.)	kg	120
Water	Dinoseb (sea)	kg	0.11
Water	Folpet (sea)	kg	16
Soil	Metazachlor (agr.)	kg	3.9
Water	o-xylene (sea)	kg	0.000015
Soil	anilazine (agr.)	kg	0.21
Soil	diisodecylphthalate (agr.)	kg	0.0046
Soil	Dichlorvos (ind.)	kg	300
Water	Anilazine	kg	1100
Water	Metobromuron	kg	430
Soil	Azinphos-ethyl (agr.)	kg	2800
Water	Aldicarb (sea)	kg	0.12
Soil	carbon disulfide (ind.)	kg	0.34
Water	Oxamyl	kg	650
Water	Chlorpyriphos (sea)	kg	0.23
Soil	Metazachlor (ind.)	kg	14
Air	2-chlorophenol	kg	13
Water	Fenthion (sea)	kg	0.26
Air	Tolclophos-methyl	kg	0.15
Soil	pentachlorobenzene (ind.)	kg	1.1
Air	dihexylphthalate	kg	0.5
Soil	MCPA (agr.)	kg	0.46
Soil	Chlorpyriphos (ind.)	kg	1400
Soil	Parathion-ethyl (agr.)	kg	500
Soil	Cyanazine (ind.)	kg	3000
Soil	Glyphosate (ind.)	kg	3.7
Air	Carbaryl	kg	110
Soil	Pyrazophos (agr.)	kg	250
Water	hexachloro-1,3-butadiene	kg	45000
Air	phenanthrene	kg	1.3
Soil	benzene (agr.)	kg	0.00072
Soil	chrysene (ind.)	kg	290
Water	Chlordane (sea)	kg	31
Water	Dimethoate (sea)	kg	0.0000074
Water	Iprodione (sea)	kg	3.8E-09
Soil	dioxin (TEQ) (agr.)	kg	120000
Soil	phenanthrene (ind.)	kg	1.2
Water	Carbaryl	kg	4500
Soil	Desmetryn (agr.)	kg	3
Water	fluoranthene (sea)	kg	0.87
Water	Bifenthrin (sea)	kg	0.055
Water	1,2,3,4-tetrachlorobenzene	kg	16
Water	Heptenophos (sea)	kg	0.0013
Soil	Dinoseb (ind.)	kg	58000
Air	cypermethrin	kg	84000
Soil	Heptenophos (ind.)	kg	120
Air	1-chloro-4-nitrobenzene	kg	11
Soil	Malathion (ind.)	kg	650
Soil	para-xylene (agr.)	kg	0.0014
Water	1,4-dichlorobenzene (sea)	kg	0.0011

Impact category	x Fresh water aquatic ecotox.	kg 1,4-DB eq	
Air	chrysene	kg	39
Soil	acrolein (ind.)	kg	45000
Air	Glyphosate	kg	22
Water	Glyphosate	kg	1400
Water	2,3,4,6-tetrachlorophenol (sea)	kg	0.0013
Water	1,2,3-trichlorobenzene (sea)	kg	0.0039
Soil	Chlorothalonil (ind.)	kg	3.7
Soil	Acephate (ind.)	kg	160
Soil	Methabenzthiazuron (ind.)	kg	140
Water	1,2-dichlorobenzene (sea)	kg	0.0013
Soil	naphtalene (ind.)	kg	12
Water	2,4-D (sea)	kg	1.1E-10
Soil	Dinoseb (agr.)	kg	20000
Soil	diisooctylphthalate (ind.)	kg	0.0025
Soil	methylbromide (ind.)	kg	0.14
Water	Demeton	kg	22000
Soil	Aldicarb (agr.)	kg	96000
Soil	Endrin (agr.)	kg	21000
Air	Heptenophos	kg	120
Soil	Folpet (ind.)	kg	13000
Air	Chlorpropham	kg	2.3
Water	2,4-dichlorophenol (sea)	kg	0.00029
Soil	Diuron (ind.)	kg	1100
Soil	Acephate (agr.)	kg	51
Soil	1,1,1-trichloroethane (agr.)	kg	0.00037
Soil	chlorobenzene (agr.)	kg	0.0032
Water	Triazophos	kg	170000
Soil	dihexylphthalate (ind.)	kg	0.074
Water	Mo (sea)	kg	6.6E-19
Soil	fluoranthene (agr.)	kg	19
Water	Sb (sea)	kg	7.6E-21
Soil	Fenthion (agr.)	kg	3500
Water	Oxamyl (sea)	kg	0.00000045
Water	Fenthion	kg	910000
Water	ethene (sea)	kg	1E-12
Water	Bentazon (sea)	kg	7.4E-09
Water	Fentin hydroxide (sea)	kg	0.029
Air	1,2,4,5-tetrachlorobenzene	kg	0.073
Water	Cu (sea)	kg	4.1E-20
Soil	Mevinfos (ind.)	kg	1500
Soil	chrysene (agr.)	kg	74
Water	1,2,3,5-tetrachlorobenzene	kg	14
Water	Iprodione	kg	160
Water	Ethoprophos	kg	150000
Water	diisodecylphthalate (sea)	kg	0.038
Water	methyl-mercury	kg	39000
Air	dinoseb	kg	10000
Soil	2,4,5-T (ind.)	kg	1.5
Soil	Methomyl (ind.)	kg	28000
Soil	Triazophos (agr.)	kg	5800
Water	diisodecylphthalate	kg	86
Soil	Cyromazine (agr.)	kg	6500
Soil	Thiram (ind.)	kg	4400
Water	Co (sea)	kg	1.2E-18
Soil	ethylbenzene (ind.)	kg	0.0018
Water	propylene oxide (sea)	kg	0.00044
Soil	vanadium (agr.)	kg	4700
Water	Dichlorprop (sea)	kg	1.6E-12
Water	chrysene	kg	19000
Water	thallium	kg	8000
Water	Chlorothalonil (sea)	kg	0.14
Water	Triazophos (sea)	kg	0.079
Air	3-chloroaniline	kg	100
Water	phenanthrene	kg	520
Soil	bifenthrin (ind.)	kg	410
Water	tetrachloromethane (sea)	kg	0.00019
Water	4-chloroaniline (sea)	kg	0.011
Water	Parathion-ethyl	kg	1200000
Soil	benzo[a]anthracene (agr.)	kg	62
Air	Chlorpyriphos	kg	520
Soil	ethylene (agr.)	kg	1.1E-09
Soil	pentachloronitrobenzene (agr.)	kg	15
Soil	Folpet (agr.)	kg	4500
Soil	anthracene (ind.)	kg	320
Air	Parathion-methyl	kg	990
Air	Lindane	kg	52
Water	trichloroethene (sea)	kg	0.000016
Water	Phoxim (sea)	kg	0.033
Soil	Heptachlor (agr.)	kg	2.3
Soil	Dimethoate (agr.)	kg	8.9
Water	Glyphosate (sea)	kg	2.1E-11
Water	3,4-dichloroaniline (sea)	kg	0.0012
Soil	benzo[ghi]perylene (agr.)	kg	61
Soil	Metolachlor (agr.)	kg	1900
Soil	Dichlorprop (ind.)	kg	0.051
Soil	1,4-dichlorobenzene (ind.)	kg	0.014
Soil	Chlordane (agr.)	kg	94
Water	Linuron (sea)	kg	0.06
Air	Metobromuron	kg	49
Soil	toluene (agr.)	kg	0.0011
Water	styrene (sea)	kg	0.00001
Air	Oxamyl	kg	56
Water	Chloridazon (sea)	kg	0.0035
Soil	Dichlorprop (agr.)	kg	0.013
Water	Ethoprophos (sea)	kg	1
Soil	phenol (ind.)	kg	13
Soil	Parathion-methyl (ind.)	kg	4400

Impact category	x Fresh water aquatic ecotox.	kg 1,4-DB eq	
Air	Chlordane	kg	270
Soil	Fentin acetate (agr.)	kg	380
Water	Metamitron (sea)	kg	6.8E-10
Water	Methabenzthiazuron	kg	1100
Air	Permethrin	kg	16000
Soil	Pyrazophos (ind.)	kg	990
Soil	4-chloroaniline (ind.)	kg	490
Air	4-chloroaniline	kg	2
Soil	thallium (agr.)	kg	4200
Air	Acephate	kg	79
Water	naphtalene	kg	660
Air	Metolachlor	kg	1500
Water	benzylchloride (sea)	kg	0.011
Soil	Ethoprophos (agr.)	kg	11000
Air	Deltamethrin	kg	1800
Soil	anilazine (ind.)	kg	0.86
Soil	Dinoterb (ind.)	kg	1300
Soil	Coumaphos (agr.)	kg	1000000
Water	Permethrin (sea)	kg	10
Air	anilazine	kg	14
Water	1,2-dichloroethane (sea)	kg	0.000088
Soil	tetrachloromethane (agr.)	kg	0.00056
Soil	tributyltinoxide (ind.)	kg	4200
Water	Pb (sea)	kg	5.6E-23
Water	dioxins (TEQ) (sea)	kg	130000
Water	naphtalene (sea)	kg	0.011
Soil	Propoxur (ind.)	kg	54000
Soil	dibutylphthalate (agr.)	kg	0.079
Air	Ethoprophos	kg	2400
Soil	diethylphthalate (ind.)	kg	0.63
Soil	Pirimicarb (ind.)	kg	5200
Water	Metazachlor (sea)	kg	0.000003
Air	Dichlorprop	kg	0.099
Water	3-chloroaniline (sea)	kg	0.0000037
Water	p-xylene	kg	0.55
Water	butylbenzylphthalate (sea)	kg	0.000032
Water	V (sea)	kg	2.4E-18
Water	Chlordane	kg	90000
Water	Cd (sea)	kg	2.5E-20
Soil	acrylonitrile (agr.)	kg	6.5
Soil	Co (agr.)	kg	1700
Soil	butylbenzylphthalate (ind.)	kg	0.1
Water	Thiram (sea)	kg	0.026
Soil	Endrin (ind.)	kg	71000
Water	benzo(ghi)perylene	kg	52000
Water	methyl-mercury (sea)	kg	160
Soil	Carbendazim (ind.)	kg	6100
Air	2,4,5-trichlorophenol	kg	15
Water	ethylene oxide (sea)	kg	0.0038
Soil	Propoxur (agr.)	kg	20000
Water	DDT (sea)	kg	15
Water	Deltamethrin (sea)	kg	3.2
Water	benzene (sea)	kg	0.0000092
Soil	antimony (agr.)	kg	10
Soil	diisooctylphthalate (agr.)	kg	0.00062
Soil	Dieldrin (ind.)	kg	2300
Water	dioctylphthalate (sea)	kg	0.00014
Water	Chlorpropham (sea)	kg	0.000028
Air	Pyrazophos	kg	180
Air	Triazophos	kg	3300
Air	Oxydemethon-methyl	kg	2400
Soil	dioctylphthalate (agr.)	kg	0.000042
Soil	Oxamyl (ind.)	kg	120
Soil	pentachlorophenol (agr.)	kg	0.33
Soil	Linuron (ind.)	kg	2400
Soil	Chloridazon (ind.)	kg	3.9
Water	Endosulfan (sea)	kg	0.021
Soil	propylene oxide (agr.)	kg	0.42
Soil	Atrazine (ind.)	kg	930
Soil	Pb (agr.)	kg	6.5
Soil	2,4-dichlorophenol (agr.)	kg	2.5
Water	benzo(k)fluoranthrene	kg	1200000
Water	Chlorfenvinphos (sea)	kg	0.000056
Soil	Metamitron (ind.)	kg	1.5
Water	hexachlorobenzene (sea)	kg	1.1
Water	o-xylene	kg	0.56
Water	Fenitrothion (sea)	kg	0.0099
Water	Coumaphos (sea)	kg	110
Water	Ni (sea)	kg	6.1E-19
Soil	indeno[1,2,3-cd]pyrene (agr.)	kg	90
Soil	PAH (carcinogenic) (agr.)	kg	58
Soil	Cyanazine (agr.)	kg	810
Soil	Zineb (agr.)	kg	370
Soil	ethylbenzene (agr.)	kg	0.0018
Soil	hexachloro-1,3-butadiene (agr.)	kg	70
Soil	Azinphos-methyl (ind.)	kg	800
Air	butylbenzylphthalate	kg	0.4
Water	Tri-allate (sea)	kg	1.1
Water	pentachlorophenol (sea)	kg	0.000012
Water	Mecoprop (sea)	kg	3.8E-10
Soil	dimethylphthalate (ind.)	kg	0.029
Water	1,2,3,4-tetrachlorobenzene (sea)	kg	0.038
Water	Methabenzthiazuron (sea)	kg	0.000092
Soil	Tolclophos-methyl (agr.)	kg	3.1
Soil	Aldicarb (ind.)	kg	96000
Air	pentachloronitrobenzene	kg	47

Impact category	x Fresh water aquatic ecotox.	kg 1,4-DB eq	
Soil	hexachloro-1,3-butadiene (ind.)	kg	84
Soil	hexachlorobenzene (agr.)	kg	3.2
Soil	vanadium (ind.)	kg	4700
Soil	bifenthrin (agr.)	kg	100
Soil	trichloroethene (agr.)	kg	0.00046
Soil	DDT (agr.)	kg	87
Water	Captafol (sea)	kg	0.00005
Water	Methomyl (sea)	kg	0.0085
Soil	Deltamethrin (ind.)	kg	96
Water	phthalic anhydride	kg	0.55
Soil	1,2-dichloroethane (agr.)	kg	0.00075
Water	diethylphthalate	kg	34
Soil	Cu (agr.)	kg	590
Water	dimethylphthalate (sea)	kg	0.00000038
Soil	Benomyl (ind.)	kg	18
Water	Permethrin	kg	5000000
Soil	1,2,3,4-tetrachlorobenzene (agr.)	kg	0.028
Air	diazinon	kg	230
Air	indeno[1,2,3-cd]pyrene	kg	170
Water	Folpet	kg	82000
Soil	Cr (III) (agr.)	kg	5.3
Air	2,3,4,6-tetrachlorophenol	kg	80
Soil	Chloridazon (agr.)	kg	1.8
Soil	benzo[k]fluoranthrene (ind.)	kg	20000
Soil	Fentin hydroxide (agr.)	kg	380
Water	Parathion-methyl (sea)	kg	0.12
Air	methomyl	kg	14000
Water	Propoxur	kg	260000
Soil	meta-xylene (ind.)	kg	0.0019
Water	Deltamethrin	kg	650000
Soil	Dimethoate (ind.)	kg	28
Water	1-chloro-4-nitrobenzene (sea)	kg	1.9
Water	methylbromide	kg	19
Water	PAH (sea)	kg	0.12
Soil	Oxydemethon-methyl (ind.)	kg	3600
Soil	Chlorothalonil (agr.)	kg	1
Water	1,2,4-trichlorobenzene (sea)	kg	0.0044
Water	1,3-dichlorobenzene	kg	1.2
Soil	benzo[k]fluoranthrene (agr.)	kg	5200
Soil	3,4-dichloroaniline (ind.)	kg	4000
Water	thallium (sea)	kg	7.9E-18
Water	Dinoseb	kg	320000
Air	anthracene	kg	140
Water	Mevinfos (sea)	kg	0.000069
Soil	Triazophos (ind.)	kg	19000
Water	Isoproturon	kg	1900
Water	tributyltinoxide (sea)	kg	3
Water	1,3-dichlorobenzene (sea)	kg	0.0011
Water	HF (sea)	kg	0.0022
Water	Azinphos-methyl (sea)	kg	0.00011
Air	Bifenthrin	kg	820
Air	diethylphthalate	kg	0.42
Soil	Aldrin (ind.)	kg	290
Water	diethylphthalate (sea)	kg	0.000079
Water	2,4,5-T	kg	17
Water	Hg (sea)	kg	6.8
Water	Cypermethrin (sea)	kg	2.4
Soil	trichloromethane (agr.)	kg	0.00047
Water	Trichlorfon (sea)	kg	0.0000053
Soil	Mecoprop (ind.)	kg	78
Air	Iprodione	kg	2.8
Water	Chlorpyriphos	kg	640000
Soil	Benomyl (agr.)	kg	4.6
Soil	Chlordane (ind.)	kg	370
Soil	3-chloroaniline (agr.)	kg	74
Soil	Ni (agr.)	kg	1700
Soil	Fenthion (ind.)	kg	14000
Water	Lindane	kg	6500
Soil	1,2,3-trichlorobenzene (agr.)	kg	0.023
Soil	tin (agr.)	kg	6.9
Water	Captafol	kg	540000
Water	Cr (VI) (sea)	kg	3.5E-22
Soil	benzo[a]anthracene (ind.)	kg	250
Water	Chlorfenvinphos	kg	1100
Water	indeno[1,2,3-cd]pyrene (sea)	kg	0.00074
Air	tri-allate	kg	61
Soil	Trichlorfon (ind.)	kg	18000
Air	pentachlorobenzene	kg	0.37
Air	2,4,5-T	kg	0.85
Soil	selenium (ind.)	kg	1500
Air	1,2,3,5-tetrachlorobenzene	kg	0.073
Water	dibutylphthalate (sea)	kg	0.000029
Water	Cr (III) (sea)	kg	8.8E-23
Water	benzo(a)pyrene (sea)	kg	0.28
Air	chlorobenzene	kg	0.00047
Soil	Fentin chloride (agr.)	kg	250
Soil	Simazine (ind.)	kg	5600
Water	chrysene (sea)	kg	0.26
Soil	1,2,3,5-tetrachlorobenzene (ind.)	kg	0.19
Soil	methylbromide (agr.)	kg	0.14
Water	Parathion-ethyl (sea)	kg	0.2
Soil	Pirimicarb (agr.)	kg	1700
Water	Pyrazophos	kg	49000
Soil	1,2,4-trichlorobenzene (agr.)	kg	0.02

Impact category	x Fresh water aquatic ecotox.	kg 1,4-DB eq	
Water	trichloromethane (sea)	kg	0.000045
Air	Captafol	kg	20000
Soil	Propachlor (ind.)	kg	64
Air	Endrin	kg	1100
Soil	Fentin chloride (ind.)	kg	990
Soil	thallium (ind.)	kg	4200
Air	Fentin hydroxide	kg	4200
Soil	1,2,3,5-tetrachlorobenzene (agr.)	kg	0.083
Air	Desmetryn	kg	6.8
Soil	Iprodione (agr.)	kg	0.23
Air	Pirimicarb	kg	2400
Air	MCPA	kg	1.1
Soil	Tri-allate (agr.)	kg	50
Soil	dioctylphthalate (ind.)	kg	0.00017
Water	1-chloro-4-nitrobenzene	kg	860
Water	vinyl chloride (sea)	kg	0.0000014
Water	Fentin hydroxide	kg	270000
Soil	gamma-HCH (Lindane) (ind.)	kg	370
Soil	butylbenzylphthalate (agr.)	kg	0.025
Air	coumaphos	kg	240000
Soil	Isoproturon (ind.)	kg	400
Soil	Captafol (agr.)	kg	27000
Water	phenol (sea)	kg	0.000017
Water	Diazinon (sea)	kg	0.064
Water	diisooctylphthalate	kg	21
Soil	antimony (ind.)	kg	10
Water	Captan (sea)	kg	0.00000065
Water	Cyromazine (sea)	kg	0.00000081
Air	3,4-dichloroaniline	kg	1700
Water	Metobromuron (sea)	kg	0.0016
Soil	Trichlorfon (agr.)	kg	3300
Soil	Chlorpyriphos (agr.)	kg	360
Soil	Desmetryn (ind.)	kg	11
Water	pentachloronitrobenzene (sea)	kg	11
Soil	2,4,5-trichlorophenol (ind.)	kg	99
Water	Anilazine (sea)	kg	0.00000011
Water	1,2,3,5-tetrachlorobenzene (sea)	kg	0.03
Air	dioctylphthalate	kg	0.016
Air	1,2,3,4-tetrachlorobenzene	kg	0.1
Water	Trifluralin (sea)	kg	1.8
Soil	1,2-dichlorobenzene (agr.)	kg	0.019
Soil	Diazinon (agr.)	kg	1300
Soil	methyl-mercury (agr.)	kg	19000
Air	1,2-dichlorobenzene	kg	0.0029
Water	Be (sea)	kg	1.6E-16
Soil	di(2-ethylhexyl)phthalate (agr.)	kg	0.0015
Air	Metazachlor	kg	7.4
Soil	2-chlorophenol (ind.)	kg	31
Water	HF	kg	19
Water	Tolclophos-methyl (sea)	kg	0.029
Soil	Chlorpropham (ind.)	kg	6.4
Soil	Co (ind.)	kg	1700
Water	Metazachlor	kg	150
Soil	Fentin acetate (ind.)	kg	1500
Water	Cyromazine	kg	26000
Water	1,3,5-trichlorobenzene (sea)	kg	0.007
Soil	Dinoterb (agr.)	kg	330
Air	Disulfothon	kg	27
Water	phthalic anhydride (sea)	kg	4.6E-11
Soil	methyl-mercury (ind.)	kg	19000
Soil	Tolclophos-methyl (ind.)	kg	9.2
Water	Desmetryn	kg	190
Water	Chlorothalonil	kg	370
Water	Pirimicarb	kg	36000
Water	formaldehyde (sea)	kg	0.00021
Soil	Linuron (agr.)	kg	690
Soil	1-chloro-4-nitrobenzene (agr.)	kg	150
Water	2,4,5-trichlorophenol	kg	1600
Soil	tributyltinoxide (agr.)	kg	1100
Water	Azinphos-ethyl (sea)	kg	0.041
Water	Chloridazon	kg	31
Water	Phoxim	kg	2600
Air	Captan	kg	16
Soil	Phoxim (agr.)	kg	4.4
Water	Tri-allate	kg	49000
Air	benzo(k)fluoranthrene	kg	3900
Water	2,4,5-T (sea)	kg	1.7E-10
Soil	beryllium (ind.)	kg	46000
Soil	Carbaryl (agr.)	kg	23
Soil	Captan (ind.)	kg	4.7
Soil	beryllium (agr.)	kg	46000
Soil	meta-xylene (agr.)	kg	0.0019
Water	Endrin (sea)	kg	6.1
Water	Metolachlor	kg	38000
Water	Aldrin (sea)	kg	1.3
Soil	tetrachloroethene (agr.)	kg	0.0022
Water	Se (sea)	kg	7.4E-18
Air	Chlorothalonil	kg	2.5
Soil	Propachlor (agr.)	kg	17
Air	cyromazine	kg	3500
Soil	Parathion-ethyl (ind.)	kg	1900
Water	ethene	kg	0.022
Water	1,1,1-trichloroethane (sea)	kg	0.000071

Impact category	x Fresh water aquatic ecotox.	kg 1,4-DB eq	
Soil	ortho-xylene (agr.)	kg	0.0025
Air	Propoxur	kg	25000
Air	Fenitrothion	kg	2500
Water	di(2-ethylhexyl)phthalate (sea)	kg	0.0016
Water	Carbendazim (sea)	kg	0.000000024
Soil	Heptenophos (agr.)	kg	31
Air	Linuron	kg	40
Soil	Endosulfan (ind.)	kg	9
Soil	Coumaphos (ind.)	kg	3100000
Soil	Phtalic anhydride (ind.)	kg	0.000031
Air	Fentin chloride	kg	1800
Water	acrylonitrile (sea)	kg	0.006
Water	Coumaphos	kg	20000000
Soil	Cr (VI) (agr.)	kg	21
Water	hexachloro-1,3-butadiene (sea)	kg	23
Soil	Trifluarin (ind.)	kg	160
Soil	DDT (ind.)	kg	340
Water	Zineb (sea)	kg	0.0036
Water	Bifenthrin	kg	240000
Water	Simazine (sea)	kg	0.0045
Air	Aldicarb	kg	51000
Soil	Cypermethrin (agr.)	kg	200000
Water	3,4-dichloroaniline	kg	19000
Water	Disulfothon (sea)	kg	0.013
Soil	barium (ind.)	kg	110
Air	cyanazine	kg	1900
Soil	Tri-allate (ind.)	kg	200
Soil	1,2,3,4-tetrachlorobenzene (ind.)	kg	0.1
Water	Metolachlor (sea)	kg	0.07
Soil	Phtalic anhydride (agr.)	kg	0.000048
Water	Linuron	kg	31000
Air	Chlorfenvinphos	kg	32
Water	Acephate	kg	1100
Water	Tolclophos-methyl	kg	500
Soil	1,2,4,5-tetrachlorobenzene (agr.)	kg	0.025
Water	m-xylene (sea)	kg	0.0000072
Soil	1,3-dichlorobenzene (ind.)	kg	0.018
Water	Endosulfan	kg	28000
Soil	Demeton (ind.)	kg	2600
Air	Benomyl	kg	30
Water	benzo(k)fluoranthrene (sea)	kg	9.1
Soil	DNOC (ind.)	kg	4.5
Air	Chloridazon	kg	0.026
Water	Carbofuran (sea)	kg	0.00018
Soil	3-chloroaniline (ind.)	kg	250
Soil	Zn (agr.)	kg	48
Air	Folpet	kg	410
Soil	Chlorfenvinphos (agr.)	kg	16
Water	1,2,4,5-tetrachlorobenzene	kg	13
Water	2-chlorophenol (sea)	kg	0.0067
Water	Benomyl (sea)	kg	0.000000089
Air	Azinphos-ethyl	kg	290
Soil	Methabenzthiazuron (agr.)	kg	44
Air	1,3-dichlorobenzene	kg	0.0024
Water	cyanazine	kg	54000
Water	2-chlorophenol	kg	1600
Soil	Endosulfan (agr.)	kg	2.2
Air	diisooctylphthalate	kg	0.12
Soil	Azinphos-ethyl (ind.)	kg	3700
Water	Zn (sea)	kg	1.8E-21
Air	methyl-mercury	kg	7300
Soil	Diazinon (ind.)	kg	4600
Water	anthracene (sea)	kg	17
Water	acrolein	kg	250000
Water	anthracene	kg	57000
Air	Phoxim	kg	0.44
Air	1,4-dichlorobenzene	kg	0.0024
Soil	Chlorfenvinphos (ind.)	kg	59
Soil	Trifluarin (agr.)	kg	40
Soil	hydrogen fluoride (agr.)	kg	9.4
Water	Ba (sea)	kg	2.4E-19
Soil	Permethrin (ind.)	kg	3700
Soil	Fentin hydroxide (ind.)	kg	1500
Air	zineb	kg	940
Soil	2,3,4,6-tetrachlorophenol (agr.)	kg	32
Water	Demeton (sea)	kg	0.017
Water	MCPA	kg	27
Water	2,3,4,6-tetrachlorophenol	kg	5200
Soil	3,4-dichloroaniline (agr.)	kg	1800
Water	DDT	kg	29000
Soil	selenium (agr.)	kg	1500
Water	Malathion (sea)	kg	0.018
Soil	2,4-D (ind.)	kg	82
Soil	PAH (carcinogenic) (ind.)	kg	230
Water	Heptachlor	kg	18000
Soil	Cyromazine (ind.)	kg	6500
Water	indeno[1,2,3-cd]pyrene	kg	77000
Water	chlorobenzene	kg	0.36
Soil	Carbofuran (ind.)	kg	1800
Soil	benzo(a)pyrene (agr.)	kg	130
Water	Heptachlor (sea)	kg	0.039
Water	Oxydemethon-methyl	kg	70000
Water	Atrazine (sea)	kg	0.0083
Soil	naphtalene (agr.)	kg	3.8

Impact category	x Fresh water aquatic ecotox.	kg 1,4-DB eq	
Soil	pentachlorobenzene (agr.)	kg	0.59
Water	Sn (sea)	kg	9.5E-23
Water	Propachlor	kg	1200
Water	1,3-butadiene (sea)	kg	0.000000056
Water	2,4,5-trichlorophenol (sea)	kg	0.054
Air	dinoterb	kg	2900
Water	pentachlorobenzene (sea)	kg	0.24
Water	DNOC (sea)	kg	0.000000021
Water	Propachlor (sea)	kg	0.0005
Soil	Carbofuran (agr.)	kg	580
Water	Fentin chloride	kg	170000
Water	diisooctylphthalate (sea)	kg	0.0039
Water	Fenitrothion	kg	240000
Soil	Disulfoton (ind.)	kg	290
Soil	Fenitrothion (agr.)	kg	760
Soil	benzo[ghi]perylene (ind.)	kg	240
Soil	Captafol (ind.)	kg	83000
Air	2,4-dichlorophenol	kg	1.4
Water	phenanthrene (sea)	kg	0.058
Soil	Carbaryl (ind.)	kg	120
Air	diisodecylphthalate	kg	0.56
Soil	anthracene (agr.)	kg	82
Soil	1,2-dichlorobenzene (ind.)	kg	0.019
Water	2,4,6-trichlorophenol (sea)	kg	0.00024
Soil	Permethrin (agr.)	kg	920
Soil	ethylene oxide (agr.)	kg	0.79
Water	MCPA (sea)	kg	5.3E-13
Water	pentachloronitrobenzene	kg	4000
Air	Isoproturon	kg	190
Water	Disulfothon	kg	64000
Air	benzo(ghi)perylene	kg	44
Soil	dichloromethane (agr.)	kg	0.00016
Soil	diisodecylphthalate (ind.)	kg	0.018
Water	ethyl benzene (sea)	kg	0.0000094
Water	Propoxur (sea)	kg	0.00012
Water	Diuron (sea)	kg	0.0019
Soil	Parathion-methyl (agr.)	kg	1100
Water	benzo(ghi)perylene (sea)	kg	0.049
Water	Dichlorprop	kg	5.3
Water	dioctylphthalate	kg	2.8
Soil	Isoproturon (agr.)	kg	170
Soil	formaldehyde (agr.)	kg	15
Soil	Methomyl (agr.)	kg	14000
Water	Zineb	kg	28000
Water	Heptenophos	kg	22000
Soil	hydrogen fluoride (ind.)	kg	9.4
Soil	dihexylphthalate (agr.)	kg	0.018
Soil	2,4,5-T (agr.)	kg	0.44
Soil	indeno[1,2,3-cd]pyrene (ind.)	kg	360
Water	pentachlorobenzene	kg	51
Soil	chlorobenzene (ind.)	kg	0.0032
Soil	ortho-xylene (ind.)	kg	0.0025
Soil	Heptachlor (ind.)	kg	8.9
Soil	Glyphosate (agr.)	kg	0.92
Water	Dimethoate	kg	170
Water	As (sea)	kg	3.8E-20
Water	3-chloroaniline	kg	2500
Soil	1,2,4,5-tetrachlorobenzene (ind.)	kg	0.09
Water	p-xylene (sea)	kg	0.00001
Water	acrolein (sea)	kg	5
Water	benzo(a)anthracene (sea)	kg	1.1
Water	Benomyl	kg	6800
Soil	tin (ind.)	kg	6.9
Soil	para-xylene (ind.)	kg	0.0014
Soil	Oxydemethon-methyl (agr.)	kg	970
Soil	1,4-dichlorobenzene (agr.)	kg	0.014
Soil	dimethylphthalate (agr.)	kg	0.0074
Water	tetrachloroethene (sea)	kg	0.0002
Water	Carbaryl (sea)	kg	0.0000019
Air	dimethylphthalate	kg	0.052
Water	Desmetryn (sea)	kg	0.0000041
Air	Demeton	kg	23
Soil	carbon disulfide (agr.)	kg	0.34
Soil	Ethoprophos (ind.)	kg	30000
Water	Azinphos-ethyl	kg	270000
Water	chlorobenzene (sea)	kg	0.00026
Soil	1,1,1-trichloroethane (ind.)	kg	0.00037
Soil	Chlorpropham (agr.)	kg	1.8
Water	dichloromethane (sea)	kg	0.000005
Air	Carbofuran	kg	900
Air	dimethoate	kg	13
Air	Endosulfan	kg	45
Soil	1-chloro-4-nitrobenzene (ind.)	kg	150
Soil	4-chloroaniline (agr.)	kg	170
Water	Isoproturon (sea)	kg	0.000029
Water	Dinoterb	kg	230000
Soil	phenanthrene (agr.)	kg	0.29
Soil	2,4,5-trichlorophenol (agr.)	kg	28
Soil	1,3-butadiene (agr.)	kg	0.000057
Soil	Metobromuron (agr.)	kg	95
Water	1,1,1-trichloroethane	kg	0.11
Soil	pentachloronitrobenzene (ind.)	kg	58
Water	Lindane (sea)	kg	0.11
Water	Chlorpropham	kg	83
Water	tributyltinoxide	kg	450000

Impact category	x Fresh water aquatic ecotox.	kg 1,4-DB eq	
Soil	Mo (ind.)	kg	260
Water	Diazinon	kg	110000
Water	Captan	kg	2100
Soil	Hg (agr.)	kg	850
Water	cyanazine (sea)	kg	0.0000025
Soil	vinyl chloride (agr.)	kg	0.000064
Soil	Cypermethrin (ind.)	kg	690000
Water	Fentin acetate (sea)	kg	0.087
Water	dihexylphthalate (sea)	kg	0.011
Water	methylbromide (sea)	kg	0.0023
Water	1,2-dichlorobenzene	kg	1
Water	1,2,4,5-tetrachlorobenzene (sea)	kg	0.029
Air	Heptachlor	kg	1.4
Soil	Phoxim (ind.)	kg	7.9
Water	Dieldrin (sea)	kg	16
Soil	Metobromuron (ind.)	kg	95
Water	Pyrazophos (sea)	kg	0.0023
Soil	Deltamethrin (agr.)	kg	24
Soil	Mo (agr.)	kg	260
Water	Endrin	kg	700000
Air	Trichlorfon	kg	13000
Soil	2,4,6-trichlorophenol (agr.)	kg	1.2
Water	Carbofuran	kg	13000
Air	Fenthion	kg	2500
Water	4-chloroaniline	kg	3100
Soil	acrolein (agr.)	kg	45000
Soil	MCPA (ind.)	kg	1.7
Water	carbon disulfide (sea)	kg	0.0065
Water	Dinoterb (sea)	kg	0.042
Water	Oxydemethon-methyl (sea)	kg	0.0003
Water	2,4-dichlorophenol	kg	170
Soil	Disulfoton (agr.)	kg	72
Water	butylbenzylphthalate	kg	76

Table B1.6 Terrestrial Ecotoxicity

Impact category	x Terrestrial ecotoxicity	kg 1,4-DB eq	
Air	1,1,1-trichloroethane	kg	0.00018
Air	1,2,3-trichlorobenzene	kg	0.075
Air	1,2,4-trichlorobenzene	kg	0.0088
Air	1,2-dichloroethane	kg	0.000026
Air	1,3,5-trichlorobenzene	kg	0.0019
Air	1,3-butadiene	kg	0.000000023
Air	2,4,6-trichlorophenol	kg	0.32
Air	2,4-D	kg	0.6
Air	acrolein	kg	16
Air	acrylonitrile	kg	0.008
Air	Aldrin	kg	0.014
Air	As	kg	1600
Air	Atrazine	kg	2
Air	Azinphos-methyl	kg	0.19
Air	Ba	kg	4.9
Air	Be	kg	1800
Air	Bentazon	kg	0.25
Air	benzene	kg	0.000016
Air	benzo(a)anthracene	kg	0.23
Air	benzo(a)pyrene	kg	0.24
Air	benzylchloride	kg	0.0017
Air	Carbendazim	kg	20
Air	Cd	kg	81
Air	cobalt	kg	110
Air	Cr (III)	kg	3000
Air	Cr (VI)	kg	3000
Air	CS2	kg	0.0051
Air	Cu	kg	7
Air	di(2-ethylhexyl)phthalate	kg	0.00022
Air	dibutylphthalate	kg	0.0039
Air	dichloromethane	kg	0.0000043
Air	Dichlorvos	kg	9.8
Air	Dieldrin	kg	1.1
Air	dioxin (TEQ)	kg	12000
Air	Diuron	kg	8.7
Air	DNOC	kg	0.24
Air	ethene	kg	1.3E-12
Air	ethylbenzene	kg	0.0000014
Air	ethylene oxide	kg	0.0025
Air	Fentin-acetate	kg	5.3
Air	fluoranthene	kg	0.018
Air	formaldehyde	kg	0.94
Air	heavy metals	kg	48.93
Air	hexachlorobenzene	kg	0.26
Air	HF	kg	0.0029
Air	Hg	kg	28000
Air	m-xylene	kg	0.00000065
Air	Malathion	kg	0.02
Air	Mecoprop	kg	1.8
Air	Metabenzthiazuron	kg	0.45
Air	metals	kg	48.93
Air	Metamitron	kg	0.019
Air	methyl bromide	kg	0.013
Air	Mevinfos	kg	43
Air	Mo	kg	18

Impact category	x Terrestrial ecotoxicity	kg 1,4-DB eq	
Air	naphthalene	kg	0.00082
Air	Ni	kg	120
Air	o-xylene	kg	0.0000013
Air	p-xylene	kg	0.00000053
Air	PAH's	kg	1
Air	Pb	kg	16
Air	pentachlorophenol	kg	2.3
Air	phenol	kg	0.0033
Air	phthalic acid anhydride	kg	0.00051
Air	propyleneoxide	kg	0.0015
Air	Sb	kg	0.61
Air	Se	kg	53
Air	Simazine	kg	8.8
Air	Sn	kg	14
Air	styrene	kg	0.00000014
Air	tetrachloroethene	kg	0.0081
Air	tetrachloromethane	kg	0.00047
Air	Thiram	kg	32
Air	Tl	kg	340
Air	toluene	kg	0.000016
Air	trichloroethene	kg	0.0000047
Air	trichloromethane	kg	0.00004
Air	Trifluralin	kg	0.017
Air	V	kg	670
Air	vinyl chloride	kg	0.00000026
Air	Zn	kg	12
Water	1,2,3-trichlorobenzene	kg	0.073
Water	1,2,4-trichlorobenzene	kg	0.0085
Water	1,2-dichloroethane	kg	0.000026
Water	1,3,5-trichlorobenzene	kg	0.0018
Water	1,3-butadiene	kg	0.000000021
Water	2,4,6-trichlorophenol	kg	0.00067
Water	2,4-D	kg	9.3E-10
Water	acrylonitrile	kg	0.0039
Water	Aldrin	kg	0.014
Water	As	kg	1E-17
Water	Atrazine	kg	0.00076
Water	Azinphos-methyl	kg	0.0000033
Water	Ba	kg	5.1E-19
Water	Be	kg	3.3E-16
Water	Bentazon	kg	0.00000018
Water	benzene	kg	0.000014
Water	benzo(a)anthracene	kg	0.014
Water	benzo(a)pyrene	kg	0.0025
Water	benzylchloride	kg	0.00083
Water	Carbendazim	kg	0.000000063
Water	Cd	kg	1.4E-20
Water	Co	kg	2.7E-18
Water	Cr (III)	kg	2.3E-19
Water	Cr (VI)	kg	2.3E-19
Water	Cu	kg	4.1E-21
Water	di(2-ethylhexyl)phthalate	kg	0.0000066
Water	dibutylphthalate	kg	0.000013
Water	dichloromethane	kg	0.0000039
Water	Dichlorvos	kg	0.014
Water	Dieldrin	kg	0.26
Water	dioxins (TEQ)	kg	590
Water	Diuron	kg	0.0017
Water	DNOC	kg	0.00000085
Water	ethyl benzene	kg	0.0000012
Water	ethylene oxide	kg	0.0018
Water	fluoranthene	kg	0.0049
Water	formaldehyde	kg	0.0016
Water	hexachlorobenzene	kg	0.26
Water	Hg	kg	930
Water	Malathion	kg	0.000011
Water	Mecoprop	kg	0.000000011
Water	metallic ions	kg	5.754E-21
Water	Metamitron	kg	8.5E-10
Water	Mevinfos	kg	0.000023
Water	Mo	kg	2.3E-18
Water	Ni	kg	1E-18
Water	PAH's	kg	0.0021
Water	Pb	kg	4.8E-22
Water	pentachlorophenol	kg	0.00032
Water	phenol	kg	0.0000025
Water	propylene oxide	kg	0.00065
Water	Sb	kg	1.7E-20
Water	Se	kg	1.6E-17
Water	Simazine	kg	0.001
Water	Sn	kg	7.9E-22
Water	styrene	kg	0.00000013
Water	tetrachloroethene	kg	0.0079
Water	tetrachloromethane	kg	0.00047
Water	Thiram	kg	0.093
Water	toluene	kg	0.000014
Water	trichloroethene	kg	0.0000046
Water	trichloromethane	kg	0.000039
Water	Trifluralin	kg	0.013
Water	V	kg	1E-17
Water	vinyl chloride	kg	0.00000026
Water	Zn	kg	2.5E-21
Soil	1,2,3-trichlorobenzene (ind.)	kg	8
Soil	1,2,4-trichlorobenzene (ind.)	kg	0.99
Soil	1,2-dichloroethane (ind.)	kg	0.0017
Soil	1,3,5-trichlorobenzene (ind.)	kg	0.22
Soil	1,3-butadiene (ind.)	kg	0.00031
Soil	2,4,6-trichlorophenol (ind.)	kg	0.68
Soil	2,4-D (agr.)	kg	1.6
Soil	acrylonitrile (ind.)	kg	2.1

Impact category	x Terrestrial ecotoxicity	kg 1,4-DB eq	
Soil	Aldrin (agr.)	kg	20
Soil	As (ind.)	kg	3300
Soil	Atrazine (agr.)	kg	6.6
Soil	Azinphos-methyl (agr.)	kg	0.97
Soil	Bentazon (agr.)	kg	0.59
Soil	benzene (ind.)	kg	0.0034
Soil	benzo(a)pyrene (ind.)	kg	23
Soil	benzylchloride (ind.)	kg	0.71
Soil	Carbendazim (agr.)	kg	49
Soil	Cd (agr.)	kg	170
Soil	Cd (ind.)	kg	170
Soil	Cr (III) (ind.)	kg	6300
Soil	Cr (VI) (ind.)	kg	6300
Soil	Cu (ind.)	kg	14
Soil	di(2-ethylhexyl)phthalate(ind)	kg	0.0014
Soil	dibutylphthalate (ind.)	kg	0.023
Soil	dichloromethane (ind.)	kg	0.00025
Soil	Dichlorvos (agr.)	kg	200
Soil	Dieldrin (agr.)	kg	110
Soil	dioxin (TEQ) (ind.)	kg	27000
Soil	Diuron (agr.)	kg	23
Soil	DNOC (agr.)	kg	0.52
Soil	ethylene oxide (ind.)	kg	0.19
Soil	fluoranthene (ind.)	kg	2.3
Soil	formaldehyde (ind.)	kg	4.4
Soil	gamma-HCH (Lindane) (agr.)	kg	23
Soil	hexachlorobenzene (ind.)	kg	3
Soil	Hg (ind.)	kg	56000
Soil	Malathion (agr.)	kg	0.076
Soil	Mecoprop (agr.)	kg	4.7
Soil	Metamitron (agr.)	kg	0.042
Soil	Mevinfos (agr.)	kg	87
Soil	Ni (ind.)	kg	240
Soil	Pb (ind.)	kg	33
Soil	pentachlorophenol (ind.)	kg	4.8
Soil	propylene oxide (ind.)	kg	0.12
Soil	Simazine (agr.)	kg	29
Soil	styrene (ind.)	kg	0.0012
Soil	tetrachloroethene (ind.)	kg	0.3
Soil	tetrachloromethane (ind.)	kg	0.0021
Soil	Thiram (agr.)	kg	51
Soil	toluene (ind.)	kg	0.019
Soil	trichloroethene (ind.)	kg	0.0021
Soil	trichloromethane (ind.)	kg	0.0016
Soil	vinyl chloride (ind.)	kg	0.00031
Soil	Zn (ind.)	kg	25
Soil	phenol (agr.)	kg	0.045
Soil	Bentazon (ind.)	kg	0.5
Water	Fentin chloride (sea)	kg	0.0025
Water	dihexylphthalate	kg	0.00026
Soil	Zineb (ind.)	kg	15
Soil	Iprodione (ind.)	kg	0.3
Water	Fentin acetate	kg	0.0061
Soil	Metolachlor (ind.)	kg	0.41
Soil	diethylphthalate (agr.)	kg	2.1
Water	Aldicarb	kg	0.19
Soil	Fenitrothion (ind.)	kg	81
Air	DDT	kg	19
Water	carbon disulfide	kg	0.0048
Water	Dichlorvos (sea)	kg	0.00022
Soil	1,3,5-trichlorobenzene (agr.)	kg	0.25
Soil	2-chlorophenol (agr.)	kg	0.38
Air	Propachlor	kg	0.54
Soil	Captan (agr.)	kg	0.041
Water	toluene (sea)	kg	0.0000019
Soil	2,4-dichlorophenol (ind.)	kg	0.54
Air	Parathion-ethyl	kg	1.1
Soil	styrene (agr.)	kg	0.0014
Soil	barium (agr.)	kg	10
Water	m-xylene	kg	0.0000006
Water	Parathion-methyl	kg	0.034
Water	Trichlorfon	kg	0.00007
Soil	Demeton (agr.)	kg	60
Water	Cypermethrin	kg	16
Soil	ethylene (ind.)	kg	2.3E-09
Water	1,4-dichlorobenzene	kg	0.012
Water	Acephate (sea)	kg	5.3E-10
Soil	1,3-dichlorobenzene (agr.)	kg	0.062
Soil	benzylchloride (agr.)	kg	0.8
Soil	Oxamyl (agr.)	kg	5.9
Air	tributyltinoxide	kg	17
Water	Pirimicarb (sea)	kg	0.000017
Water	Methomyl	kg	0.0022
Water	dimethylphthalate	kg	0.00037
Air	hexachloro-1,3-butadiene	kg	4.2
Soil	As (agr.)	kg	3300
Soil	2,3,4,6-tetrachlorophenol (ind.)	kg	0.97
Water	Dinoseb (sea)	kg	0.001
Water	Folpet (sea)	kg	0.074
Soil	Metazachlor (agr.)	kg	0.17
Water	o-xylene (sea)	kg	0.00000021
Soil	anilazine (agr.)	kg	0.23
Soil	diisodecylphthalate (agr.)	kg	0.004
Soil	Dichlorvos (ind.)	kg	200
Water	Anilazine	kg	0.00000005
Water	Metobromuron	kg	0.00046
Soil	Azinphos-ethyl (agr.)	kg	220

Impact category	x Terrestrial ecotoxicity	kg 1,4-DB eq	
Water	Aldicarb (sea)	kg	0.0048
Soil	carbon disulfide (ind.)	kg	1.6
Water	Oxamyl	kg	0.0000071
Water	Chlorpyriphos (sea)	kg	0.000057
Soil	Metazachlor (ind.)	kg	0.15
Air	2-chlorophenol	kg	0.053
Water	Fenthion (sea)	kg	0.0017
Air	Tolclophos-methyl	kg	0.00034
Soil	pentachlorobenzene (ind.)	kg	1.7
Air	dihexylphthalate	kg	0.00078
Soil	MCPA (agr.)	kg	0.094
Soil	Chlorpyriphos (ind.)	kg	17
Soil	Parathion-ethyl (agr.)	kg	17
Soil	Cyanazine (ind.)	kg	63
Soil	Glyphosate (ind.)	kg	0.096
Air	Carbaryl	kg	0.063
Soil	Pyrazophos (agr.)	kg	30
Water	hexachloro-1,3-butadiene	kg	4
Air	phenanthrene	kg	0.00014
Soil	benzene (agr.)	kg	0.0034
Soil	chrysene (ind.)	kg	4.5
Water	Chlordane (sea)	kg	0.28
Water	Dimethoate (sea)	kg	0.00000018
Water	Iprodione (sea)	kg	1.5E-10
Soil	dioxin (TEQ) (agr.)	kg	27000
Soil	phenanthrene (ind.)	kg	0.037
Water	Carbaryl	kg	0.00000026
Soil	Desmetryn (agr.)	kg	2.9
Water	fluoranthene (sea)	kg	0.00096
Water	Bifenthrin (sea)	kg	0.00059
Water	1,2,3,4-tetrachlorobenzene	kg	0.0093
Water	Heptenophos (sea)	kg	0.000024
Soil	Dinoseb (ind.)	kg	420
Air	cypermethrin	kg	8900
Soil	Heptenophos (ind.)	kg	16
Air	1-chloro-4-nitrobenzene	kg	0.54
Soil	Malathion (ind.)	kg	0.075
Soil	para-xylene (agr.)	kg	0.0015
Water	1,4-dichlorobenzene (sea)	kg	0.0057
Air	chrysene	kg	0.22
Soil	acrolein (ind.)	kg	7000
Air	Glyphosate	kg	0.047
Water	Glyphosate	kg	2.2E-11
Water	2,3,4,6-tetrachlorophenol (sea)	kg	0.0000052
Water	1,2,3-trichlorobenzene (sea)	kg	0.035
Soil	Chlorothalonil (ind.)	kg	0.61
Soil	Acephate (ind.)	kg	1.3
Soil	Methabenzthiazuron (ind.)	kg	0.88
Water	1,2-dichlorobenzene (sea)	kg	0.00024
Soil	naphtalene (ind.)	kg	2.6
Water	2,4-D (sea)	kg	1.8E-12
Soil	Dinoseb (agr.)	kg	590
Soil	diisooctylphthalate (ind.)	kg	0.00055
Soil	methylbromide (ind.)	kg	0.37
Water	Demeton	kg	0.012
Soil	Aldicarb (agr.)	kg	4200
Soil	Endrin (agr.)	kg	4200
Air	Heptenophos	kg	2.2
Soil	Folpet (ind.)	kg	78
Air	Chlorpropham	kg	0.037
Water	2,4-dichlorophenol (sea)	kg	0.0000062
Soil	Diuron (ind.)	kg	19
Soil	Acephate (agr.)	kg	1.7
Soil	1,1,1-trichloroethane (agr.)	kg	0.0015
Soil	chlorobenzene (agr.)	kg	0.12
Water	Triazophos	kg	0.039
Soil	dihexylphthalate (ind.)	kg	0.0073
Water	Mo (sea)	kg	2.9E-18
Soil	fluoranthene (agr.)	kg	2.3
Water	Sb (sea)	kg	3E-20
Soil	Fenthion (agr.)	kg	290
Water	Oxamyl (sea)	kg	0.000000023
Water	Fenthion	kg	0.088
Water	ethene (sea)	kg	9.9E-14
Water	Bentazon (sea)	kg	3.3E-10
Water	Fentin hydroxide (sea)	kg	0.000038
Air	1,2,4,5-tetrachlorobenzene	kg	0.24
Water	Cu (sea)	kg	2.5E-20
Soil	Mevinfos (ind.)	kg	90
Soil	chrysene (agr.)	kg	4.6
Water	1,2,3,5-tetrachlorobenzene	kg	0.17
Water	Iprodione	kg	0.000000044
Water	Ethoprophos	kg	0.24
Water	diisodecylphthalate (sea)	kg	0.000064
Water	methyl-mercury	kg	930
Air	dinoseb	kg	97
Soil	2,4,5-T (ind.)	kg	0.64
Soil	Methomyl (ind.)	kg	220
Soil	Triazophos (agr.)	kg	250
Water	diisodecylphthalate	kg	0.00038
Soil	Cyromazine (agr.)	kg	630
Soil	Thiram (ind.)	kg	81
Water	Co (sea)	kg	4.9E-18
Soil	ethylbenzene (ind.)	kg	0.0019
Water	propylene oxide (sea)	kg	0.000018
Soil	vanadium (agr.)	kg	1400
Water	Dichlorprop (sea)	kg	1.1E-14
Water	chrysene	kg	0.0084
Water	thallium	kg	3.1E-17

Impact category	x Terrestrial ecotoxicity	kg 1,4-DB eq	
Water	Chlorothalonil (sea)	kg	0.00038
Water	Triazophos (sea)	kg	0.00084
Air	3-chloroaniline	kg	0.47
Water	phenanthrene	kg	0.00006
Soil	bifenthrin (ind.)	kg	83
Water	tetrachloromethane (sea)	kg	0.00036
Water	4-chloroaniline (sea)	kg	0.000086
Water	Parathion-ethyl	kg	0.0031
Soil	benzo[a]anthracene (agr.)	kg	31
Air	Chlorpyriphos	kg	0.13
Soil	ethylene (agr.)	kg	2.3E-09
Soil	pentachloronitrobenzene (agr.)	kg	2.7
Soil	Folpet (agr.)	kg	110
Soil	anthracene (ind.)	kg	8.8
Air	Parathion-methyl	kg	5.7
Air	Lindane	kg	1.8
Water	trichloroethene (sea)	kg	0.0000019
Water	Phoxim (sea)	kg	0.0013
Soil	Heptachlor (agr.)	kg	5.5
Soil	Dimethoate (agr.)	kg	0.8
Water	Glyphosate (sea)	kg	4.4E-14
Water	3,4-dichloroaniline (sea)	kg	0.0000067
Soil	benzo[ghi]perylene (agr.)	kg	8.3
Soil	Metolachlor (agr.)	kg	0.54
Soil	Dichlorprop (ind.)	kg	0.0014
Soil	1,4-dichlorobenzene (ind.)	kg	1
Soil	Chlordane (agr.)	kg	74
Water	Linuron (sea)	kg	0.00031
Air	Metobromuron	kg	0.99
Soil	toluene (agr.)	kg	0.019
Water	styrene (sea)	kg	0.000000027
Air	Oxamyl	kg	2.9
Water	Chloridazon (sea)	kg	0.000064
Soil	Dichlorprop (agr.)	kg	0.0014
Water	Ethoprophos (sea)	kg	0.0072
Soil	phenol (ind.)	kg	0.041
Soil	Parathion-methyl (ind.)	kg	79
Air	Chlordane	kg	2.2
Soil	Fentin acetate (agr.)	kg	12
Water	Metamitron (sea)	kg	1.4E-11
Water	Methabenzthiazuron	kg	0.00002
Air	Permethrin	kg	26
Soil	Pyrazophos (ind.)	kg	29
Soil	4-chloroaniline (ind.)	kg	11
Air	4-chloroaniline	kg	0.016
Soil	thallium (agr.)	kg	700
Air	Acephate	kg	0.69
Water	naphtalene	kg	0.00049
Air	Metolachlor	kg	0.11
Water	benzylchloride (sea)	kg	0.000025
Soil	Ethoprophos (agr.)	kg	270
Air	Deltamethrin	kg	0.76
Soil	anilazine (ind.)	kg	0.23
Soil	Dinoterb (ind.)	kg	9.9
Soil	Coumaphos (agr.)	kg	16000
Water	Permethrin (sea)	kg	0.017
Air	anilazine	kg	0.092
Water	1,2-dichloroethane (sea)	kg	0.00002
Soil	tetrachloromethane (agr.)	kg	0.0021
Soil	tributyltinoxide (ind.)	kg	37
Water	Pb (sea)	kg	4.6E-21
Water	dioxins (TEQ) (sea)	kg	830
Water	naphtalene (sea)	kg	0.000019
Soil	Propoxur (ind.)	kg	1300
Soil	dibutylphthalate (agr.)	kg	0.023
Air	Ethoprophos	kg	17
Soil	diethylphthalate (ind.)	kg	2.1
Soil	Pirimicarb (ind.)	kg	94
Water	Metazachlor (sea)	kg	0.00000003
Air	Dichlorprop	kg	0.00068
Water	3-chloroaniline (sea)	kg	0.000000017
Water	p-xylene	kg	0.00000049
Water	butylbenzylphthalate (sea)	kg	0.0000001
Water	V (sea)	kg	2.2E-17
Water	Chlordane	kg	0.097
Water	Cd (sea)	kg	1.1E-19
Soil	acrylonitrile (agr.)	kg	2.5
Soil	Co (agr.)	kg	220
Soil	butylbenzylphthalate (ind.)	kg	0.01
Water	Thiram (sea)	kg	0.00031
Soil	Endrin (ind.)	kg	3600
Water	benzo(ghi)perylene	kg	0.00043
Water	methyl-mercury (sea)	kg	7600
Soil	Carbendazim (ind.)	kg	38
Air	2,4,5-trichlorophenol	kg	0.24
Water	ethylene oxide (sea)	kg	0.000097
Soil	Propoxur (agr.)	kg	1800
Water	DDT (sea)	kg	0.96
Water	Deltamethrin (sea)	kg	0.0014
Water	benzene (sea)	kg	0.0000017
Soil	antimony (agr.)	kg	1.3
Soil	diisooctylphthalate (agr.)	kg	0.00055
Soil	Dieldrin (ind.)	kg	100
Water	dioctylphthalate (sea)	kg	0.000000088
Water	Chlorpropham (sea)	kg	0.00000045
Air	Pyrazophos	kg	2.3
Air	Triazophos	kg	34
Air	Oxydemethon-methyl	kg	41
Soil	dioctylphthalate (agr.)	kg	0.000048

Impact category	x Terrestrial ecotoxicity	kg 1,4-DB eq	
Soil	Oxamyl (ind.)	kg	6
Soil	pentachlorophenol (agr.)	kg	4.8
Soil	Linuron (ind.)	kg	18
Soil	Chloridazon (ind.)	kg	0.68
Water	Endosulfan (sea)	kg	0.000016
Soil	propylene oxide (agr.)	kg	0.14
Soil	Atrazine (ind.)	kg	4.4
Soil	Pb (agr.)	kg	33
Soil	2,4-dichlorophenol (agr.)	kg	0.59
Water	benzo(k)fluoranthrene	kg	0.21
Water	Chlorfenvinphos (sea)	kg	0.00000086
Soil	Metamitron (ind.)	kg	0.038
Water	hexachlorobenzene (sea)	kg	0.24
Water	o-xylene	kg	0.0000012
Water	Fenitrothion (sea)	kg	0.000084
Water	Coumaphos (sea)	kg	0.5
Water	Ni (sea)	kg	2.6E-18
Soil	indeno[1,2,3-cd]pyrene (agr.)	kg	13
Soil	PAH (carcinogenic) (agr.)	kg	6.3
Soil	Cyanazine (agr.)	kg	69
Soil	Zineb (agr.)	kg	16
Soil	ethylbenzene (agr.)	kg	0.0019
Soil	hexachloro-1,3-butadiene (agr.)	kg	53
Soil	Azinphos-methyl (ind.)	kg	1
Air	butylbenzylphthalate	kg	0.0013
Water	Tri-allate (sea)	kg	0.00013
Water	pentachlorophenol (sea)	kg	0.0000026
Water	Mecoprop (sea)	kg	1.8E-11
Soil	dimethylphthalate (ind.)	kg	1.4
Water	1,2,3,4-tetrachlorobenzene (sea)	kg	0.0037
Water	Methabenzthiazuron (sea)	kg	0.0000006
Soil	Tolclophos-methyl (agr.)	kg	1.8
Soil	Aldicarb (ind.)	kg	4200
Air	pentachloronitrobenzene	kg	0.12
Soil	hexachloro-1,3-butadiene (ind.)	kg	47
Soil	hexachlorobenzene (agr.)	kg	3.5
Soil	vanadium (ind.)	kg	1400
Soil	bifenthrin (agr.)	kg	83
Soil	trichloroethene (agr.)	kg	0.0021
Soil	DDT (agr.)	kg	60
Water	Captafol (sea)	kg	0.000000016
Water	Methomyl (sea)	kg	0.000075
Soil	Deltamethrin (ind.)	kg	8.5
Water	phthalic anhydride	kg	1.2E-10
Soil	1,2-dichloroethane (agr.)	kg	0.0017
Water	diethylphthalate	kg	0.0056
Soil	Cu (agr.)	kg	14
Water	dimethylphthalate (sea)	kg	0.0000047
Soil	Benomyl (ind.)	kg	3.5
Water	Permethrin	kg	0.39
Soil	1,2,3,4-tetrachlorobenzene (agr.)	kg	0.83
Air	diazinon	kg	0.29
Air	indeno[1,2,3-cd]pyrene	kg	0.8
Water	Folpet	kg	0.6
Soil	Cr (III) (agr.)	kg	6300
Air	2,3,4,6-tetrachlorophenol	kg	0.31
Soil	Chloridazon (agr.)	kg	0.9
Soil	benzo[k]fluoranthrene (ind.)	kg	390
Soil	Fentin hydroxide (agr.)	kg	12
Water	Parathion-methyl (sea)	kg	0.00071
Air	methomyl	kg	120
Water	Propoxur	kg	0.00031
Soil	meta-xylene (ind.)	kg	0.003
Water	Deltamethrin	kg	0.032
Soil	Dimethoate (ind.)	kg	0.62
Water	1-chloro-4-nitrobenzene (sea)	kg	0.096
Water	methylbromide	kg	0.011
Water	PAH (sea)	kg	0.00081
Soil	Oxydemethon-methyl (ind.)	kg	85
Soil	Chlorothalonil (agr.)	kg	0.68
Water	1,2,4-trichlorobenzene (sea)	kg	0.004
Water	1,3-dichlorobenzene	kg	0.00042
Soil	benzo[k]fluoranthrene (agr.)	kg	390
Soil	3,4-dichloroaniline (ind.)	kg	18
Water	thallium (sea)	kg	4.2E-17
Water	Dinoseb	kg	0.34
Air	anthracene	kg	0.032
Water	Mevinfos (sea)	kg	0.00000032
Soil	Triazophos (ind.)	kg	200
Water	Isoproturon	kg	0.000016
Water	tributyltinoxide (sea)	kg	0.0069
Water	1,3-dichlorobenzene (sea)	kg	0.0002
Water	HF (sea)	kg	0.000045
Water	Azinphos-methyl (sea)	kg	0.000000049
Air	Bifenthrin	kg	8.8
Air	diethylphthalate	kg	0.53
Soil	Aldrin (ind.)	kg	20
Water	diethylphthalate (sea)	kg	0.0001
Water	2,4,5-T	kg	0.000000036
Water	Hg (sea)	kg	7600
Water	Cypermethrin (sea)	kg	0.25
Soil	trichloromethane (agr.)	kg	0.0016
Water	Trichlorfon (sea)	kg	0.00000048
Soil	Mecoprop (ind.)	kg	3.3

Impact category	x Terrestrial ecotoxicity	kg 1,4-DB eq	
Air	Iprodione	kg	0.11
Water	Chlorpyriphos	kg	0.021
Soil	Benomyl (agr.)	kg	3.5
Soil	Chlordane (ind.)	kg	73
Soil	3-chloroaniline (agr.)	kg	1.4
Soil	Ni (agr.)	kg	240
Soil	Fenthion (ind.)	kg	280
Water	Lindane	kg	0.16
Soil	1,2,3-trichlorobenzene (agr.)	kg	9.3
Soil	tin (agr.)	kg	30
Water	Captafol	kg	0.00000019
Water	Cr (VI) (sea)	kg	2E-18
Soil	benzo[a]anthracene (ind.)	kg	31
Water	Chlorfenvinphos	kg	0.000046
Water	indeno[1,2,3-cd]pyrene (sea)	kg	0.0000041
Air	tri-allate	kg	0.0069
Soil	Trichlorfon (ind.)	kg	2600
Air	pentachlorobenzene	kg	0.039
Air	2,4,5-T	kg	0.32
Soil	selenium (ind.)	kg	110
Air	1,2,3,5-tetrachlorobenzene	kg	0.18
Water	dibutylphthalate (sea)	kg	0.00000021
Water	Cr (III) (sea)	kg	2E-18
Water	benzo(a)pyrene (sea)	kg	0.0008
Air	chlorobenzene	kg	0.00073
Soil	Fentin chloride (agr.)	kg	12
Soil	Simazine (ind.)	kg	21
Water	chrysene (sea)	kg	0.0016
Soil	1,2,3,5-tetrachlorobenzene (ind.)	kg	12
Soil	methylbromide (agr.)	kg	0.36
Water	Parathion-ethyl (sea)	kg	0.000082
Soil	Pirimicarb (agr.)	kg	120
Water	Pyrazophos	kg	0.0017
Soil	1,2,4-trichlorobenzene (agr.)	kg	1.2
Water	trichloromethane (sea)	kg	0.000019
Air	Captafol	kg	5.9
Soil	Propachlor (ind.)	kg	2.3
Air	Endrin	kg	49
Soil	Fentin chloride (ind.)	kg	11
Soil	thallium (ind.)	kg	700
Air	Fentin hydroxide	kg	5.5
Soil	1,2,3,5-tetrachlorobenzene (agr.)	kg	15
Air	Desmetryn	kg	1.2
Soil	Iprodione (agr.)	kg	0.14
Air	Pirimicarb	kg	46
Air	MCPA	kg	0.043
Soil	Tri-allate (agr.)	kg	1.3
Soil	dioctylphthalate (ind.)	kg	0.000048
Water	1-chloro-4-nitrobenzene	kg	0.44
Water	vinyl chloride (sea)	kg	0.00000013
Water	Fentin hydroxide	kg	0.0021
Soil	gamma-HCH (Lindane) (ind.)	kg	22
Soil	butylbenzylphthalate (agr.)	kg	0.01
Air	coumaphos	kg	1000
Soil	Isoproturon (ind.)	kg	4.6
Soil	Captafol (agr.)	kg	28
Water	phenol (sea)	kg	0.000000038
Water	Diazinon (sea)	kg	0.000082
Water	diisooctylphthalate	kg	0.0000064
Soil	antimony (ind.)	kg	1.3
Water	Captan (sea)	kg	9.4E-10
Water	Cyromazine (sea)	kg	0.000000073
Air	3,4-dichloroaniline	kg	8.7
Water	Metobromuron (sea)	kg	0.000038
Soil	Trichlorfon (agr.)	kg	1900
Soil	Chlorpyriphos (agr.)	kg	17
Soil	Desmetryn (ind.)	kg	2.6
Water	pentachloronitrobenzene (sea)	kg	0.029
Soil	2,4,5-trichlorophenol (ind.)	kg	3.9
Water	Anilazine (sea)	kg	7E-10
Water	1,2,3,5-tetrachlorobenzene (sea)	kg	0.074
Air	dioctylphthalate	kg	0.0000098
Air	1,2,3,4-tetrachlorobenzene	kg	0.0099
Water	Trifluralin (sea)	kg	0.003
Soil	1,2-dichlorobenzene (agr.)	kg	0.054
Soil	Diazinon (agr.)	kg	12
Soil	methyl-mercury (agr.)	kg	56000
Air	1,2-dichlorobenzene	kg	0.00053
Water	Be (sea)	kg	3.9E-16
Soil	di(2-ethylhexyl)phthalate (agr.)	kg	0.0014
Air	Metazachlor	kg	0.074
Soil	2-chlorophenol (ind.)	kg	0.37
Water	HF	kg	0.000045
Water	Tolclophos-methyl (sea)	kg	0.000067
Soil	Chlorpropham (ind.)	kg	0.12
Soil	Co (ind.)	kg	220
Water	Metazachlor	kg	0.0000014
Soil	Fentin acetate (ind.)	kg	11
Water	Cyromazine	kg	0.0000019
Water	1,3,5-trichlorobenzene (sea)	kg	0.00083
Soil	Dinoterb (agr.)	kg	9.9
Air	Disulfothon	kg	0.043
Water	phthalic anhydride (sea)	kg	2.8E-12

Impact category	x Terrestrial ecotoxicity	kg 1,4-DB eq	
Soil	methyl-mercury (ind.)	kg	56000
Soil	Tolclophos-methyl (ind.)	kg	1.5
Water	Desmetryn	kg	0.000036
Water	Chlorothalonil	kg	0.0055
Water	Pirimicarb	kg	0.00093
Water	formaldehyde (sea)	kg	0.000024
Soil	Linuron (agr.)	kg	21
Soil	1-chloro-4-nitrobenzene (agr.)	kg	17
Water	2,4,5-trichlorophenol	kg	0.061
Soil	tributyltinoxide (agr.)	kg	37
Water	Azinphos-ethyl (sea)	kg	0.00034
Water	Chloridazon	kg	0.00038
Water	Phoxim	kg	0.015
Air	Captan	kg	0.024
Soil	Phoxim (agr.)	kg	4.7
Water	Tri-allate	kg	0.0027
Air	benzo(k)fluoranthrene	kg	30
Water	2,4,5-T (sea)	kg	6.4E-11
Soil	beryllium (ind.)	kg	3600
Soil	Carbaryl (agr.)	kg	0.11
Soil	Captan (ind.)	kg	0.12
Soil	beryllium (agr.)	kg	3600
Soil	meta-xylene (agr.)	kg	0.003
Water	Endrin (sea)	kg	0.38
Water	Metolachlor	kg	0.00021
Water	Aldrin (sea)	kg	0.0067
Soil	tetrachloroethene (agr.)	kg	0.3
Water	Se (sea)	kg	1.8E-17
Air	Chlorothalonil	kg	0.0071
Soil	Propachlor (agr.)	kg	2.5
Air	cyromazine	kg	310
Soil	Parathion-ethyl (ind.)	kg	17
Water	ethene	kg	1.1E-12
Water	1,1,1-trichloroethane (sea)	kg	0.0001
Soil	ortho-xylene (agr.)	kg	0.0034
Air	Propoxur	kg	700
Air	Fenitrothion	kg	21
Water	di(2-ethylhexyl)phthalate (sea)	kg	0.00000096
Water	Carbendazim (sea)	kg	1.6E-10
Soil	Heptenophos (agr.)	kg	16
Air	Linuron	kg	0.2
Soil	Endosulfan (ind.)	kg	2.8
Soil	Coumaphos (ind.)	kg	12000
Soil	Phtalic anhydride (ind.)	kg	0.00042
Air	Fentin chloride	kg	0.26
Water	acrylonitrile (sea)	kg	0.00012
Water	Coumaphos	kg	6
Soil	Cr (VI) (agr.)	kg	6300
Water	hexachloro-1,3-butadiene (sea)	kg	2.1
Soil	Trifluarin (ind.)	kg	34
Soil	DDT (ind.)	kg	59
Water	Zineb (sea)	kg	0.000028
Water	Bifenthrin	kg	0.021
Water	Simazine (sea)	kg	0.000019
Air	Aldicarb	kg	2000
Soil	Cypermethrin (agr.)	kg	90000
Water	3,4-dichloroaniline	kg	0.00076
Water	Disulfothon (sea)	kg	0.000021
Soil	barium (ind.)	kg	10
Air	cyanazine	kg	31
Soil	Tri-allate (ind.)	kg	1.3
Soil	1,2,3,4-tetrachlorobenzene (ind.)	kg	0.77
Water	Metolachlor (sea)	kg	0.0000054
Soil	Phtalic anhydride (agr.)	kg	0.0026
Water	Linuron	kg	0.011
Air	Chlorfenvinphos	kg	0.49
Water	Acephate	kg	0.000000022
Water	Tolclophos-methyl	kg	0.00032
Soil	1,2,4,5-tetrachlorobenzene (agr.)	kg	19
Water	m-xylene (sea)	kg	0.00000011
Soil	1,3-dichlorobenzene (ind.)	kg	0.062
Water	Endosulfan	kg	0.0018
Soil	Demeton (ind.)	kg	49
Air	Benomyl	kg	0.47
Water	benzo(k)fluoranthrene (sea)	kg	0.088
Soil	DNOC (ind.)	kg	0.49
Air	Chloridazon	kg	0.00046
Water	Carbofuran (sea)	kg	0.00000061
Soil	3-chloroaniline (ind.)	kg	1.2
Soil	Zn (agr.)	kg	25
Air	Folpet	kg	1.7
Soil	Chlorfenvinphos (agr.)	kg	1.3
Water	1,2,4,5-tetrachlorobenzene	kg	0.23
Water	2-chlorophenol (sea)	kg	0.000027
Water	Benomyl (sea)	kg	1.4E-09
Air	Azinphos-ethyl	kg	2.4
Soil	Methabenzthiazuron (agr.)	kg	1.1
Air	1,3-dichlorobenzene	kg	0.00044
Water	cyanazine	kg	0.0000022
Water	2-chlorophenol	kg	0.0013
Soil	Endosulfan (agr.)	kg	2.7
Air	diisooctylphthalate	kg	0.00011
Soil	Azinphos-ethyl (ind.)	kg	72
Water	Zn (sea)	kg	1.9E-20
Air	methyl-mercury	kg	28000

Impact category	x Terrestrial ecotoxicity	kg 1,4-DB eq	
Soil	Diazinon (ind.)	kg	10
Water	anthracene (sea)	kg	0.004
Water	acrolein	kg	5.8
Water	anthracene	kg	0.02
Air	Phoxim	kg	0.017
Air	1,4-dichlorobenzene	kg	0.012
Soil	Chlorfenvinphos (ind.)	kg	1.2
Soil	Trifluarin (agr.)	kg	35
Soil	hydrogen fluoride (agr.)	kg	0.006
Water	Ba (sea)	kg	6.6E-19
Soil	Permethrin (ind.)	kg	250
Soil	Fentin hydroxide (ind.)	kg	11
Air	zineb	kg	7.2
Soil	2,3,4,6-tetrachlorophenol (agr.)	kg	1
Water	Demeton (sea)	kg	0.00023
Water	MCPA	kg	1.4E-11
Water	2,3,4,6-tetrachlorophenol	kg	0.0017
Soil	3,4-dichloroaniline (agr.)	kg	26
Water	DDT	kg	0.31
Soil	selenium (agr.)	kg	110
Water	Malathion (sea)	kg	0.0000002
Soil	2,4-D (ind.)	kg	1.1
Soil	PAH (carcinogenic) (ind.)	kg	6.3
Water	Heptachlor	kg	0.00053
Soil	Cyromazine (ind.)	kg	630
Water	indeno[1,2,3-cd]pyrene	kg	0.0000062
Water	chlorobenzene	kg	0.00072
Soil	Carbofuran (ind.)	kg	5.9
Soil	benzo(a)pyrene (agr.)	kg	23
Water	Heptachlor (sea)	kg	0.000024
Water	Oxydemethon-methyl	kg	0.00046
Water	Atrazine (sea)	kg	0.00005
Soil	naphtalene (agr.)	kg	3.1
Soil	pentachlorobenzene (agr.)	kg	2.1
Water	Sn (sea)	kg	7.2E-21
Water	Propachlor	kg	0.00081
Water	1,3-butadiene (sea)	kg	0.000000004
Water	2,4,5-trichlorophenol (sea)	kg	0.00091
Air	dinoterb	kg	3.4
Water	pentachlorobenzene (sea)	kg	0.026
Water	DNOC (sea)	kg	1.5E-09
Water	Propachlor (sea)	kg	0.000013
Soil	Carbofuran (agr.)	kg	7.5
Water	Fentin chloride	kg	0.092
Water	diisooctylphthalate (sea)	kg	0.0000035
Water	Fenitrothion	kg	0.0047
Soil	Disulfoton (ind.)	kg	11
Soil	Fenitrothion (agr.)	kg	83
Soil	benzo[ghi]perylene (ind.)	kg	8.3
Soil	Captafol (ind.)	kg	22
Air	2,4-dichlorophenol	kg	0.03
Water	phenanthrene (sea)	kg	0.0000063
Soil	Carbaryl (ind.)	kg	0.14
Air	diisodecylphthalate	kg	0.00092
Soil	anthracene (agr.)	kg	8.9
Soil	1,2-dichlorobenzene (ind.)	kg	0.054
Water	2,4,6-trichlorophenol (sea)	kg	0.000013
Soil	Permethrin (agr.)	kg	250
Soil	ethylene oxide (agr.)	kg	0.22
Water	MCPA (sea)	kg	2.2E-14
Water	pentachloronitrobenzene	kg	0.05
Air	Isoproturon	kg	2.5
Water	Disulfothon	kg	0.0012
Air	benzo(ghi)perylene	kg	0.2
Soil	dichloromethane (agr.)	kg	0.00025
Soil	diisodecylphthalate (ind.)	kg	0.004
Water	ethyl benzene (sea)	kg	0.0000001
Water	Propoxur (sea)	kg	0.0000032
Water	Diuron (sea)	kg	0.000032
Soil	Parathion-methyl (agr.)	kg	81
Water	benzo(ghi)perylene (sea)	kg	0.00025
Water	Dichlorprop	kg	6.1E-12
Water	dioctylphthalate	kg	0.00000013
Soil	Isoproturon (agr.)	kg	6.4
Soil	formaldehyde (agr.)	kg	5.8
Soil	Methomyl (agr.)	kg	300
Water	Zineb	kg	0.0013
Water	Heptenophos	kg	0.0016
Soil	hydrogen fluoride (ind.)	kg	0.006
Soil	dihexylphthalate (agr.)	kg	0.0073
Soil	2,4,5-T (agr.)	kg	0.74
Soil	indeno[1,2,3-cd]pyrene (ind.)	kg	13
Water	pentachlorobenzene	kg	0.038
Soil	chlorobenzene (ind.)	kg	0.12
Soil	ortho-xylene (ind.)	kg	0.0034
Soil	Heptachlor (ind.)	kg	5.3
Soil	Glyphosate (agr.)	kg	0.096
Water	Dimethoate	kg	0.000012
Water	As (sea)	kg	3E-17
Water	3-chloroaniline	kg	0.0000094
Soil	1,2,4,5-tetrachlorobenzene (ind.)	kg	17
Water	p-xylene (sea)	kg	0.000000089
Water	acrolein (sea)	kg	0.16
Water	benzo(a)anthracene (sea)	kg	0.0062
Water	Benomyl	kg	0.000000082
Soil	tin (ind.)	kg	30
Soil	para-xylene (ind.)	kg	0.0015

Impact category	x Terrestrial ecotoxicity	kg 1,4-DB eq	
Soil	Oxydemethon-methyl (agr.)	kg	92
Soil	1,4-dichlorobenzene (agr.)	kg	1
Soil	dimethylphthalate (agr.)	kg	1.4
Water	tetrachloroethene (sea)	kg	0.004
Water	Carbaryl (sea)	kg	1.1E-09
Air	dimethylphthalate	kg	0.64
Water	Desmetryn (sea)	kg	0.00000075
Air	Demeton	kg	0.3
Soil	carbon disulfide (agr.)	kg	1.6
Soil	Ethoprophos (ind.)	kg	190
Water	Azinphos-ethyl	kg	0.021
Water	chlorobenzene (sea)	kg	0.00041
Soil	1,1,1-trichloroethane (ind.)	kg	0.0015
Soil	Chlorpropham (agr.)	kg	0.13
Water	dichloromethane (sea)	kg	0.00000065
Air	Carbofuran	kg	3
Air	dimethoate	kg	0.3
Air	Endosulfan	kg	0.036
Soil	1-chloro-4-nitrobenzene (ind.)	kg	17
Soil	4-chloroaniline (agr.)	kg	16
Water	Isoproturon (sea)	kg	0.00000038
Water	Dinoterb	kg	0.013
Soil	phenanthrene (agr.)	kg	0.037
Soil	2,4,5-trichlorophenol (agr.)	kg	4.4
Soil	1,3-butadiene (agr.)	kg	0.00031
Soil	Metobromuron (agr.)	kg	2.2
Water	1,1,1-trichloroethane	kg	0.00018
Soil	pentachloronitrobenzene (ind.)	kg	2.6
Water	Lindane (sea)	kg	0.0039
Water	Chlorpropham	kg	0.000025
Water	tributyltinoxide	kg	0.11
Soil	Mo (ind.)	kg	36
Water	Diazinon	kg	0.0041
Water	Captan	kg	0.000000062
Soil	Hg (agr.)	kg	56000
Water	cyanazine (sea)	kg	0.00000004
Soil	vinyl chloride (agr.)	kg	0.00031
Soil	Cypermethrin (ind.)	kg	78000
Water	Fentin acetate (sea)	kg	0.00011
Water	dihexylphthalate (sea)	kg	0.000017
Water	methylbromide (sea)	kg	0.00091
Water	1,2-dichlorobenzene	kg	0.00052
Water	1,2,4,5-tetrachlorobenzene (sea)	kg	0.095
Air	Heptachlor	kg	0.00088
Soil	Phoxim (ind.)	kg	3.8
Water	Dieldrin (sea)	kg	0.1
Soil	Metobromuron (ind.)	kg	2.2
Water	Pyrazophos (sea)	kg	0.000029
Soil	Deltamethrin (agr.)	kg	8.5
Soil	Mo (agr.)	kg	36
Water	Endrin	kg	0.35
Air	Trichlorfon	kg	1200
Soil	2,4,6-trichlorophenol (agr.)	kg	0.7
Water	Carbofuran	kg	0.000035
Air	Fenthion	kg	16
Water	4-chloroaniline	kg	0.0036
Soil	acrolein (agr.)	kg	7000
Soil	MCPA (ind.)	kg	0.086
Water	carbon disulfide (sea)	kg	0.001
Water	Dinoterb (sea)	kg	0.000051
Water	Oxydemethon-methyl (sea)	kg	0.0000052
Water	2,4-dichlorophenol	kg	0.00096
Soil	Disulfoton (agr.)	kg	11
Water	butylbenzylphthalate	kg	0.0000066

Table B1.7 Photochemical Oxidation

Impact category	Photochemical oxidation	kg C2H2	
Air	1,1,1-trichloroethane	kg	0.009
Air	1,2,3-trimethylbenzene	kg	1.27
Air	1,2,4-trimethylbenzene	kg	1.28
Air	1,3,5-trimethylbenzene	kg	1.38
Air	1,3-butadiene	kg	0.85
Air	1-butene	kg	1.08
Air	1-butoxy propanol	kg	0.463
Air	1-hexene	kg	0.874
Air	1-methoxy-2-propanol	kg	0.355
Air	1-pentene	kg	0.977
Air	2,2-dimethylbutane	kg	0.241
Air	2,3-dimethylbutane	kg	0.541
Air	2-butoxyethanol	kg	0.483
Air	2-ethoxyethanol	kg	0.386
Air	2-methoxyethanol	kg	0.307
Air	2-methyl-1-butanol	kg	0.489
Air	2-methyl-1-butene	kg	0.771
Air	2-methyl-2-butanol	kg	0.228
Air	2-methyl-2-butene	kg	0.842
Air	2-methyl hexane	kg	0.411
Air	2-methyl pentane	kg	0.42
Air	3,5-diethyltoluene	kg	1.3
Air	3,5-dimethylethylbenzene	kg	1.32
Air	3-methyl-1-butanol	kg	0.433
Air	3-methyl-1-butene	kg	0.671
Air	3-methyl-2-butanol	kg	0.406
Air	3-methyl hexane	kg	0.364

Impact category	Photochemical oxidation	kg C2H2	
Air	3-methyl pentane	kg	0.479
Air	3-pentanol	kg	0.595
Air	acetaldehyde	kg	0.641
Air	acetic acid	kg	0.097
Air	acetone	kg	0.094
Air	benzaldehyde	kg	-0.092
Air	benzene	kg	0.22
Air	butane	kg	0.352
Air	CO	kg	0.027
Air	cyclohexane	kg	0.29
Air	cyclohexanol	kg	0.518
Air	cyclohexanone	kg	0.299
Air	decane	kg	0.384
Air	diacetone alcohol	kg	0.307
Air	dichloromethane	kg	0.068
Air	diethyl ether	kg	0.445
Air	dimethyl ether	kg	0.189
Air	dodecane	kg	0.357
Air	ethane	kg	0.123
Air	ethanol	kg	0.399
Air	ethene	kg	1
Air	ethyl t-butyl ether	kg	0.244
Air	ethylacetate	kg	0.209
Air	ethylbenzene	kg	0.73
Air	ethylene glycol	kg	0.373
Air	ethyne	kg	0.085
Air	formaldehyde	kg	0.52
Air	formic acid	kg	0.032
Air	heptane	kg	0.494
Air	hexane	kg	0.482
Air	i-butane	kg	0.307
Air	i-butanol	kg	0.36
Air	i-butyraldehyde	kg	0.514
Air	i-propyl acetate	kg	0.211
Air	i-propyl benzene	kg	0.5
Air	isoprene	kg	1.09
Air	isopropanol	kg	0.188
Air	m-ethyl toluene	kg	1.02
Air	m-xylene	kg	1.1
Air	methane	kg	0.006
Air	methanol	kg	0.14
Air	methyl acetate	kg	0.059
Air	methyl chloride	kg	0.005
Air	methyl formate	kg	0.027
Air	methyl i-propyl ketone	kg	0.49
Air	methyl t-butyl ether	kg	0.175
Air	methyl t-butyl ketone	kg	0.323
Air	neopentane	kg	0.173
Air	NO	kg	-0.427
Air	NO2	kg	0.028
Air	nonane	kg	0.414
Air	o-ethyl toluene	kg	0.898
Air	o-xylene	kg	1.1
Air	octane	kg	0.453
Air	p-ethyl toluene	kg	0.906
Air	p-xylene	kg	1
Air	pentanal	kg	0.765
Air	pentane	kg	0.395
Air	propane	kg	0.176
Air	propene	kg	1.12
Air	s-butanol	kg	0.4
Air	s-butyl acetate	kg	0.275
Air	SO2	kg	0.048
Air	styrene	kg	0.14
Air	t-butanol	kg	0.106
Air	t-butyl acetate	kg	0.053
Air	tetrachloroethene	kg	0.029
Air	toluene	kg	0.64
Air	trichloroethene	kg	0.33
Air	trichloromethane	kg	0.023
Air	hexan-3-one	kg	0.599
Air	1-butyl acetate	kg	0.269
Air	cis-2-pentene	kg	1.12
Air	1-butanol	kg	0.62
Air	cis-dichloroethene	kg	0.447
Air	dimethyl carbonate	kg	0.025
Air	butyraldehyde	kg	0.795
Air	2-butanone	kg	0.373
Air	propylene glycol	kg	0.457
Air	hexan-2-one	kg	0.572
Air	diisopropylether	kg	0.398
Air	trans-2-pentene	kg	1.12
Air	isopentane	kg	0.405
Air	propanoic acid	kg	0.15
Air	cis-2-hexene	kg	1.07
Air	trans-2-butene	kg	1.13
Air	diethylketone	kg	0.414
Air	1-propyl acetate	kg	0.282
Air	dimethoxy methane	kg	0.16
Air	1-undecane	kg	0.384
Air	trans-2-hexene	kg	1.07
Air	methyl propyl ketone	kg	0.548
Air	trans-dichloroethene	kg	0.392
Air	1-propanol	kg	0.561
Air	i-butene	kg	0.627
Air	1-propyl benzene	kg	0.636
Air	propionaldehyde	kg	0.798
Air	cis-2-butene	kg	1.15

Table B1.8 Acidification

Impact category	Acidification	kg SO2 eq	
Air	ammonia	kg	1.6
Air	NO2	kg	0.5
Air	NOx	kg	0.5
Air	NOx (as NO2)	kg	0.5
Air	SO2	kg	1.2
Air	SOx	kg	1.2
Air	SOx (as SO2)	kg	1.2

Table B1.9 Eutrophication

Impact category	Eutrophication	kg PO4--- eq	
Air	ammonia	kg	0.35
Air	nitrates	kg	0.1
Air	NO	kg	0.2
Air	NO2	kg	0.13
Air	NOx (as NO2)	kg	0.13
Air	P	kg	3.06
Air	phosphate	kg	1
Water	COD	kg	0.022
Water	NH3	kg	0.35
Water	NH4+	kg	0.33
Water	nitrate	kg	0.1
Water	P2O5	kg	1.34
Water	phosphate	kg	1
Water	NH3 (sea)	kg	0.35
Soil	phosphor (ind.)	kg	3.06
Soil	nitrogen (ind.)	kg	0.42
Soil	phosphoric acid (ind.)	kg	0.97
Soil	ammonia (agr.)	kg	0.35
Soil	phosphate (ind.)	kg	1
Soil	ammonium (ind.)	kg	0.33
Water	phosphate (sea)	kg	1
Soil	ammonium (agr.)	kg	0.33
Soil	nitric acid (agr.)	kg	0.1
Soil	nitric acid (ind.)	kg	0.1
Water	COD (sea)	kg	0.022
Water	HNO3 (sea)	kg	0.1
Water	P	kg	3.06
Soil	ammonia (ind.)	kg	0.35
Soil	phosphoric acid (agr.)	kg	0.97
Water	phosphoric acid	kg	0.97
Water	nitrogen (sea)	kg	0.42
Water	nitrate (sea)	kg	0.1
Soil	nitrate (ind.)	kg	0.1
Soil	nitrate (agr.)	kg	0.1
Water	NH4+ (sea)	kg	0.33
Water	phosphoric acid (sea)	kg	0.97
Soil	phosphor (agr.)	kg	3.06
Air	phosphoric acid	kg	0.97
Soil	phosphate (agr.)	kg	1
Water	nitrogen	kg	0.42
Soil	nitrogen (agr.)	kg	0.42
Water	P (sea)	kg	3.06
Air	ammonium	kg	0.33
Water	HNO3	kg	0.1
Air	HNO3	kg	0.1
Water	nitrite	kg	0.1
Air	N2	kg	0.42
Water	P2O5 (sea)	kg	1.34
Air	P2O5	kg	1.34
Soil	P2O5 (ind.)	kg	1.34
Soil	P2O5 (agr.)	kg	1.34
Water	nitrite (sea)	kg	0.1

Annex C

Peer Review Report and Response

Date
Stockholm 30 July 2004
Our Reference.

Your date
Your reference

Critical Review of "Life Cycle Assessment of Disposable and Reusable Nappies, June 2004"

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IVL Swedish Environmental Research Institute
Box 21060, SE-100 31 Stockholm
31 July 2004

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1 Introduction

1.1 General

I have reviewed the study Life Cycle Assessment of Disposable and Reusable Nappies, dated June 2004, prepared by Environmental Resources Management (ERM) for the Environment Agency in U.K. [1]. This review is undertaken for the Environment Agency.

1.2 Goal and scope of this critical review

1.2.1 International standards ISO 14040 - 14043

The form for a critical review or peer review is described in the international standard ISO 14040 [2]. Specific advice is also given in the standards ISO 14041 (Goal and scope definition and inventory analysis) [3], ISO 14042 (Life cycle impact assessment) [4] and ISO 14043 (Life cycle interpretation) [5]. According to the ISO 14040 [1] the critical review process shall ensure that:

- the methods used to carry out the LCA are consistence with this International Standard;
- the methods used to carry out the LCA are scientifically and technically valid;
- the data used are appropriate and reasonable in relation to the goal of the study;
- the interpretations reflect the limitations identified and the goal of the study;
- the study report is transparent and consistent.

The ISO 14040 gives alternatives to carry out the critical review. This review is an External Expert Review, that has do be carried out by an external expert, independent of the LCA study.

1.2.2 The requirements on this critical review

The ISO 14040 [2] states that the scope and type of critical review desired shall be defined in the scope phase of an LCA study. The goal and scope for this particular study is defined in the Section 3.10 in the report:

- *for the goal and scope*:
  - ensure that the scope of the study is consistent with the goal of the study, and that both are consistent with ISO 14041; and
  - prepare a review statement on the goal and scope. This review statement will be included in the final report and detail ERM’s responses to the review.

- *for the inventory*:
  - review the inventory for transparency and consistency with the goal and scope and with ISO14041;
  - check data validation and that the data used are consistent with the system boundaries. It is unreasonable to expect the reviewer to check data and calculations beyond a small sample; and

- prepare a review statement.

- *for the impact assessment*:
  - review the impact assessment for appropriateness and conformity to ISO14042; and
  - prepare a review statement.

- *for the interpretation*:
  - review the conclusions of the study for appropriateness and conformity with the goal and scope of the study; and
  - prepare a review statement.

- *for the draft final report*:
  - review the draft final report for consistency with reporting guidelines in ISO 14040 and check that recommendations made in previous review statements have been addressed adequately; and
  - prepare a review statement including consistency of the study and international standards, scientific and technical validity, transparency and relation between interpretation, limitations and goal.

1.3 The review process

The work with the review has been undertaken according to the following:

- On June 18 I had a meeting with Environment Agency (Terry Coleman) and ERM (Michael Collins and Simon Aumônier) in London. The project was presented and the project circumstances were explained. I received an older draft version of the report (dated February 2004) for general information; ERM still had to update some of the modelling.
- On the 30 June I received an updated version of the report. This is the version that has been reviewed.
- A draft of the review statement was sent to Environment Agency (Terry Coleman) on July 15 for comments.
- The final version of the review statement was sent to Environment Agency on August 1.

I have also received an earlier review of the Goal and Scope stage, prepared by Göran Finnveden and Anna Björklund [6]. That review considered only the goal and scope stage of the study, and parts of the goals and scope have been changed since then. I have reused some of their remarks in the review of the goal and scope, where applicable.

2 Critical review statement

In general the report is extensive and written in clear and accessible language. The report describes the work adequately. The international standards in ISO 14040, ISO 14041, ISO 14042 and ISO 14043 has been adequately followed. However, the report needs some improvements and clarification. I have very few criticisms about how the work has been conducted. Most of my remarks concern how the work, and different assumptions and choices made during the work, have been presented in the report.

In ISO 14040 [2] special attention is given to comparative assertions, where different products are compared with each other. The extensive and demanding ISO 14040 guidelines for comparative assertions have been following adequately.

2.1 Goal and scope

2.1.1 Goal

The ISO 14040 [2] comments that since the standard does not specify requirements on the goals or uses of LCA, a critical review can neither verify nor validate the goals that are chosen for an LCA, or the uses to which LCA results are put.

The goal of the study is in general clearly defined and consistent with the intended application. I have the following remarks:

- The goal could be further specified by noting that the study is concerned with children's nappies use in 2001 - 2002.

PRACTITIONER'S RESPONSE: The reference to the time period has been added.

- One of the part goals or objectives has been "*to compare the results of the study with other key life cycle studies in this area and to identify the main reasons for any significant differences*". Such comparison has not been presented in report. In Chapter 1 of the report, there is a short overview of previous studies used as input to the study. The general conclusion of the overview is that the previous studies have been limited, insufficient, and not considered the latest developments in LCA methodology. This can be a motive for amending the goal and scope, and to delete this sub-goal from the goal and scope section.

PRACTITIONER'S RESPONSE: A note has been added to the report: 'This objective was considered superfluous due to the developments in LCA methodology, with nappies themselves and because the study is UK specific.'

2.1.2 Scope

The scope of the study is generally clearly defined and consistent with the intended application. I have the following remarks.

Functional unit

The choice of functional unit ("*the use of nappies during the first two and a half years of a child's life"*) is adequate, but can be clarified. It should be clarified that there is an U.K. child, and that the use of nappies is refered to 2001 - 2002.

PRACTITIONER'S RESPONSE: This has been done.

Nevertheless, the work with quantifying the functional unit, and to avoid uncertain assumptions about nappy use, is exemplary.

System boundaries

The system boundaries are defined according to ISO 14041 [3], but should be further specified.

Beside the ISO standard there has since long been a scientific discussion about system boundaries in LCA. For example, Guinée [7] sets up the following types of system boundaries:

1. Boundaries between the product system and the natural environment
2. Boundaries between significant and insignificant processes
3. Boundaries between the product system under study and other product systems (allocation).

PRACTITIONER'S RESPONSE: We would like to reiterate that the study is consistent with the International Standard for LCA, this is agreed by the reviewer. System boundaries can always be better defined. To this end, we have amended the report to address the comments below.

Also time can be added as a fourth system boundary [6].

Since ISO 14041 [3] states that "any decisions to omit life cycle stages, processes or inputs/outputs shall be clearly stated and justified" I suggest that the system boundaries be better defined according to the following.

- The first type of system boundary is relevant when modelling agriculture and forestry. For example, if the parents choose reusable cloth nappies, this will result in alternative use of the forest, be it for alternative products, alternative crops, recreational use etc., and if disposable nappies are used this would lead to alternative use of cotton fields. These secondary affects, though likely to be significant, are generally ignored in LCA studies. Though it is common practice to ignore, I believe the report should state that they have been ignored. This should be added to the goal and scope and be reiterated in the interpretation section.

PRACTITIONER'S RESPONSE: We have added text to this effect.
'This study addressed flows to and from the environment for each life cycle stage. However, the study excluded the environmental implications of land occupation and use. For example, the implications of alternative land use and the affects of land use changes were excluded. The systems assessed were considered to be steady state.'

- The second type of system boundary (between significant and insignificant processes) are discussed and considered adequately in the report.

- About the third type of system boundary (allocation) some comments can be made. Section 3.3 explains that "*inputs and outputs of the inter-related product systems have been apportioned in a manner that reflects the underlying physical relationships between them*". However, other allocation principles have been used in the study, e.g., energy consumption by the retail sector has been apportioned according to the monetary value of sales. This is allowed according to ISO 14041 [3], when physical relationship alone cannot be established or used as basis for the allocation. Section 3.3 in the report should include a statement that economic value is also used as the allocation basis.

PRACTITIONER'S RESPONSE: This has been done.

- The fourth type of system boundary (time) is relevant for landfilling of waste. A cut-off time of 100 years is used for gas emissions in the software tool WISARD that has been used in the study to model the waste management in the study. I would question whether 100 years is reasonable considering that waste may not be fully degraded by this point in time. I accept that WISARD was peer reviewed and that it was developed reflecting UK landfills and best scientific understanding. I suggest that the issue of system boundary compatibility is discussed within the report and that the 100-year cut off be assessed for significance and as to whether it is reasonable.

PRACTITIONER'S RESPONSE: A description of *WISARD* has been added to the report. With regard to time boundary, the *WISARD* tool uses a 100 year cut off for landfill gas and a 500 year cut off for leachate. These periods were determined so as to account for the majority of the emissions. The landfill model assumes 23% fugitive emission of landfill gas and 77% combustion (41% flare and 36% energy recovery) of landfill gas over its life. When developing the life cycle inventory model for landfill, the issue of time frame was studied as a sensitivity. The simulated landfill models, in the *WISARD* R&D report for landfill, all result in gas generation approaching zero m^3/hr after 60 years, from highs of between 1000 and 6000 m^3/hr.

Criteria for inclusion and exclusion
The inclusions and exclusions in Section 3.4 are in accordance with the scope of the international standard ISO 14041 [3]. Often the resource depletion and environmental impact connected to construction of equipment and buildings are negligible compared to the resource depletion and environmental impact during the operational phase. This is especially true for energy-intensive processes. In this study the energy-intensive studies are dominant. Also workforce burdens are usually excluded in LCA studies, often because there is no generally accepted method to handle these burdens.

The report presents assumptions as to how excreta are disposed of or treated for disposable nappies and home laundered reusable nappies (section 3.4.3). However, nothing is mentioned about excreta from commercial laundered reusable nappies. It is not obvious that the excreta on the commercial laundered nappies are handled the same way as the home laundered.

PRACTITIONER'S RESPONSE: Text has been added to the report stating that excreta has been handled in the same way.

Other points
In Section 3.6.6 it is declared that "*the foreground and background systems have been specified clearly in the report*". Such specification is not found in the report. This also raises questions when it in the report is referred to the foreground and background system.

PRACTITIONER'S RESPONSE: mention of the terms foreground and background have been removed and more detailed descriptions added.

Section 3.7 declares some important flows, which are presented more in detail. I interpret that the list is the important inputs and outputs to/from the studied system. Solid waste generation is included in the list. However, if treatment of solid waste is handled within the system boundary, then the solid waste is an internal flow and does not leave the system. It is therefore not something that should be reported in the inventory analysis, but it is an important internal flow. Whether solid waste is flow leaving the system or an internal flow should be clarified. In the latter case it should not be listed in section 3.7, but can be mentioned as an important internal flow.

PRACTITIONER'S RESPONSE: solid waste as been labelled as an internal flow.

The software WISARD has been used for modelling the waste management in the system. Since waste management is an important part of the system the report should include a goal and scope description of WISARD (in an appendix).

PRACTITIONER'S RESPONSE: Documentation relating to *WISARD* has been added as an Annex.

2.2 Inventory

I have in general found that the inventory is transparent and consistent with the goal and scope and with ISO 14041 [3]. Data have been collected from different sources, and my judgement is that the best available data have been used. As far as possible data have been gathered from scientific measurements (surveys), validated LCI databases (e.g. EDANA, BUWAL, WISARD) or literature. I have also checked a small sample of data and found that appropriate data have been chosen and used. All data and all calculations seem reasonable - with a few exceptions that are commented on below. Uncertainties in data have been subjected to sensitivity analysis.

I have found the following:

- As already mentioned above, I find the presentation of waste flows a little confusing. According to ISO 14040 "*Inventory analysis involves data collection and calculation procedures to quantify relevant inputs and outputs of a product system*". I consider the waste management system to be a part of the product system. Consequently waste flows should not be reported as outputs (as in Table 4.1).
-

PRACTITIONER'S RESPONSE: solid waste as been labelled as an internal flow.

- There is also some lack of clarity about the treatment of waste from manufacture, which should be clarified. :
  - Waste from manufacture is recorded for disposable nappies, but not for reusable. Can these wastes be neglected?
  - Details of the management of manufacturing waste should be given. For disposable nappies, the report describes how the municipal solid waste is treated, but not how manufacturing wastes are managed.

PRACTITIONER'S RESPONSE: Text and data relating to solid waste from the both disposable and reusable nappy manufacture has been added to the report.

- The WISARD software is used to model the waste disposal. In the modelling some key assumptions have been made, e.g. how is the energy recovered (heat or electricity) in incineration, is gas recovered from the landfill and how is it utilised, how is the leachate from the landfill treated. These assumptions are necessary for the transparency. These assumptions should be clearly stated.
-

PRACTITIONER'S RESPONSE: This information has been added to *Section 4.6*.

- The description of different unit processes is rather poor. According to ISO 14041 Clause 8, the study report should include qualitative and quantitative description of unit processes. The understanding of the processes, and their environmental impact, in manufacture, retail, use and disposal can increase if the different processes are better described. However, I am aware that a more detailed description can have both advantages and disadvantages. The advantages are that the life cycle is better understood, and the transparency is increased. The disadvantages are that the report will be more extensive and perhaps more difficult to read. I suggest that at least a summarised description be put in an Appendix.

PRACTITIONER'S RESPONSE: Additional process description of disposable nappy manufacture, cotton production and reusable nappy production has been added to the relevant sections. Though further description maybe of benefit, we feel that the references and the inventory data provided are comprehensive as to what has been modelled with regard to inputs and outputs from processes.

- In Chapter 7 the inventory results are presented in tables for the main flows. I have noted that there is some inconsistency for the BOD and COD results. Both BOD and

COD are measures of the organic content in wastewater (leachate from landfill is one type of wastewater). Usually BOD and COD are measured in different ways: BOD by biological oxidation and COD by chemical oxidation. COD gives a measure of the total (at least the total chemically oxidizable content), and BOD gives a measure of how much is biologically oxidizable. Thus the BOD content is usually a part of the COD content. For all common wastewaters the ratio BOD/COD ≤ 1. When the inventory analysis is presented is should be expected that BOD/COD ≤ 1. COD for leachate water from landfill (disposable nappy system) are reported to be = 0, while the BOD is 0,84 kg (Table 7.1), 0,613 kg (Table 7.2) or 0,013 kg (Table 7.3). Although neither BOD nor COD are strictly inventory flows, the COD = 0 from waste management should be clarified.

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PRACTITIONER'S RESPONSE: We agree that the COD number is erroneous and this has been noted in the inventory analysis section and is addressed in the sensitivity analysis section.

2.3 Environmental impact

I have found that the impact assessment is appropriate and conforms to ISO 14042. The selection of impact categories, category indicators and characterisation models has been described.

The characterisation model used in the study is CML version 2.02 updated in September 2001. The CML model is internationally accepted. I feel it necessary to point out that updated CML characterisation factors were published earlier this year [8]. I would therefore suggest that the report is either revised using the new characterisation factors, or an assessment of significance is conducted. The report has stated the impact assessment method used, and has included the characterisation factors used within report, as required by ISO. It is my understanding that the changes that have been made affect the global warming and ozone depletion impact categories.

PRACTITIONER'S RESPONSE: We agree that amendments have been made by CML and that these were not incorporated into our assessment. The characterisation factors we have used are those published in the Handbook on Life Cycle, Final editor Jeroen B. Guinee, 2002. However, we have compared the versions, the one we have used and the most recent CML version with regard to the implications for this study and found the changes to be insignificant. No difference was found for ozone depletion. The implications for global warming would be a 2% increase in GHG emission for disposable nappy systems and a 1% increase in GHG emission for the home laundered system.

I agree with the statements about human toxicity and aquatic and terrestrial eco-toxicity. The accuracy of these impact models is questionable, and the results from these impact categories should be interpreted very cautiously, as stated in the report.

The impact results of the study have been normalised. The environmental impact from U.K. nappies is put in relation to total European impacts. This normalisation procedure is according to the ISO standard.

2.4 Interpretation

The study has been adequately interpreted according to the international standard ISO 14043. According to this standard the objectives with the interpretation are to analyse results, reach conclusions, explain limitations and provide recommendations based on the findings from the study. This has been done in an exemplary manner.

2.5 Final report

The requirements for an LCA report are given in ISO 14040 [2]. In general the reporting accords with the standard. However, the report has some omissions. There are cases where data, methods, assumptions and limitations are not totally transparent and/or are not presented in sufficient detail to allow the reader to comprehend the complexities and trade-offs inherent in the LCA study. Those cases have all been mentioned and discussed above. In sections 2.1 - 2.4 in this review report, I have made some comments and suggestions for revising and completing the report. These remarks are particularly connected to the description and definition of system boundaries.

Earlier, a review has been conducted for the Goal and Scope stage [6]. I have found that some of the remarks given in that review do not appear to have been considered. I have taken up those, which are relevant, for example:

- the time aspects should be defined in the goal and scope
- completing the allocation discussion, how to allocate when "underlying physical relationships" is not possible.
- the cut-off time for the landfill should be clarified
- solid waste generation is noted as an output, although it is an internal flow.

Moreover, I have some further comments concerning the reporting:

- The references should be given more clearly. The references are clear enough for a skilled LCA practitioner. However, because the study is also for a wider audience it is recommended that the references be given more clearly so that also the intended audience can identify and search the relevant sources. This is particularly important for the data sources mentioned in Tables 4.4 **(new version Table 4.5)**, 5.12 **(new version Table 5.9)** and 6.8.

PRACTITIONER'S RESPONSE: More detailed references have been included.

- The following sentence in Section 3.5 "*All assumption will be recorded and reported in the final report*" is unclear. All assumptions should be recorded and reported in the version that is critically reviewed.

PRACTITIONER'S RESPONSE: Agree and report has been amended.

- References to data sources in the inventory are not clear. For disposable nappies the data sources for e.g. manufacture is given in Table 4.4, while the manufacture is mentioned in Section 4.1 and Table 4.1 without references to data sources. This criticism is also valid for Chapter 5 and 6 where the data sources are first shown at the end of the chapter.

PRACTITIONER'S RESPONSE: Though the reviewer considers this less helpful, the presentation in a summary table of all flows and data sources in our view aids rapid appreciation of the systems assessed and how they have been modelled. To this end we have included cross references in the report.

Some headings are a little confusing. Chapter 4, 5 and 6 is named Inventory analysis (respectively for each nappy system). Then Chapter 7 is also named Inventory analysis (with secondary headings for each nappy system). The naming of these should be revised.

PRACTITIONER'S RESPONSE: Titles have been amended.

- Table 5.9 seems to be a copy of Table 1.11 except for Nitrogen and Water. Table 5.10 seems to be a copy of Table 1.12 except for contents of "Other". Table 5.11 seems to be an identical copy of Table 1.9. The purposes of the differences between the tables in Chapter 5 and Chapter 1 should be explained. I also think it is unnecessary to have the tables duplicated or almost duplicated. It would be sufficient to refer to the tables in Chapter 1 and explain and justify the differences.

PRACTITIONER'S RESPONSE: The duplicates were an error and have been removed.

- The name of Chapter 9 should be changed. The chapter does not touch the interpretation. The normalisation section (9.9) may be moved to the impact assessment chapter (Chapter 8). In ISO 14042 the normalisation is a part of the environmental impact assessment.

PRACTITIONER'S RESPONSE: Titles have been changed.

- Appendix A and Appendix B should change places. It is more logical to have the Inventory before the impact assessment.

PRACTITIONER'S RESPONSE: Agree.

2.6 Conclusions

This critical review can be summarised as the following:

- the methods used to carry out the LCA are consistence with this International Standard;
- the methods used to carry out the LCA are scientifically and technically valid;
- the data used are in general appropriate and reasonable in relation to the goal of the study;
- the interpretations reflect the limitations identified and the goal of the study;

- the study report is not always transparent and consistent. The report should be revised to deal the aspects identified in this review.

3 References

1. Environmental Resource Management, Life Cycle Assessment of Disposable and Reusable Nappies. June 2004. Draft Final Report - Work in Progress.

2. ISO 14040. Environmental management - Life cycle assessment - Principles and framework. European Committee for Standardization 1997

3. ISO 14041. Environmental management - Life Cycle Assessment - Goal and scope definition and inventory analysis. European Committee for Standardization 1998

4. ISO 14042. Environmental management - Life cycle assessment - Life cycle impact assessment. European Committee for Standardization 2000.

5. ISO 14043. Environmental management - Life cycle assessment - Life cycle interpretation. European Committee for Standardization 2000.

6. Finnveden and Anna Björklund [6], Critical review of the draft 'LCA of Reusable and Disposable Nappies: Goal and Scope', November 2002, prepared by Environmental Resources Management for the Environment Agency, dated 2003-01-10).

7. Guinée, J.B. (Editor): Handbook on Life Cycle Assessment. Operational Guide to the ISO standard. Kluwer Academic Publishers.2002

8. CML, Institute of Environmental Science, Leiden University, April 2004, http://www.leidenuniv.nl/interfac/cml/ssp/index.html

Annex D

WISARD

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1. Foreword

The purpose of this document is to

- gather all information to be entered by the user,
- clearly state the assumptions (allocation rules, end of life of buildings) that have been made to finish the system description,
- explain how environment and economic simulations are carried out.

Background

The Environment Agency's Life Cycle Research programme was started four years ago. The aim of the programme is to provide an objective basis for the. comparison of waste management strategies and of options for individual waste types and to give waste managers the capability to assess this themselves. The programme investigates the environmental inputs and outputs, both energy and raw materials, and the related impacts of waste management options from cradle to / grave. !

To this end the programme has explored the application of Life Cycle Assessment (LCA) techniques to waste management. LCA techniques provide an objective basis to improve the decision making process for waste managers and planners in regard to managing their waste. LCA, combined with an evaluation of associated internal costs, is increasingly being used to determine best practice with industry , consistent with the demands of meeting BA TNEEC.

Programme Direction

The Environment Agency's programme includes the following five phases: Phase

1. Methodological guidelines for inventory analysis
2. Data collection and inventory analysis

   a) Impact assessment

   b) Damage cost valuation

4. Software development

5. Decision tool applications

Allocation Rules for *WISARD*

Allocation rules for *WISARD* were defined during the early stages of the Environment Agency's programme. Phases one and two of the programme should have already defined the allocation rules and checked that these are correct. Ensuring that the allocation rules for the programme are consistent was part of another process and not specifically part of the development of the tool. Allocation rules used throughout WISARD are described in this manual.

1.1 Data Transparency

Information pages for data sets in *WISARD have* been compiled and are included in the Appendices of this report.

2. Methodology

1.2 Scope of the tool

The purpose of the software (*WISARD* 3.3) is to quantify the environmental impact of collecting and processing municipal solid waste using life cycle assessment techniques.

The software tool has been designed to respond to the following questions:

- What impact do the various stages of municipal solid waste management have and what is their relative importance?
- What are the technical parameters that influence this and what actions can be taken as levers to reduce the impact of waste processing?
- How do alternative or "future" scenarios compare with reference scenario?

Figure 1 shows the scope of the *WISARD* program and summarises the various stages included in the analysis of the system. Waste is either placed on the kerb in a container or sack for collection or brought to a designated location for example, a recycling bank located at a shopping centre. The waste is collected, transported and either recovered or disposed of. The user must also describe reprocessing for those materials that have been recovered. Chemicals, consumables, energy and fuels used for the total system are also considered in *WISARD.*

WISARD has been developed following the guidelines described in the ISO 140401 series of standards.

1.3 Functional Unit

The collection and treatment of municipal solid waste generated by a local community (or a group of local communities) for a period of one year. The purpose of defining this functional unit is to compare alternative scenarios using the same service provided to the community as a starting point.

I ISO IS 14040, "Environmental Management- Life Cycle Assessment- Principles and framework", March 1997.

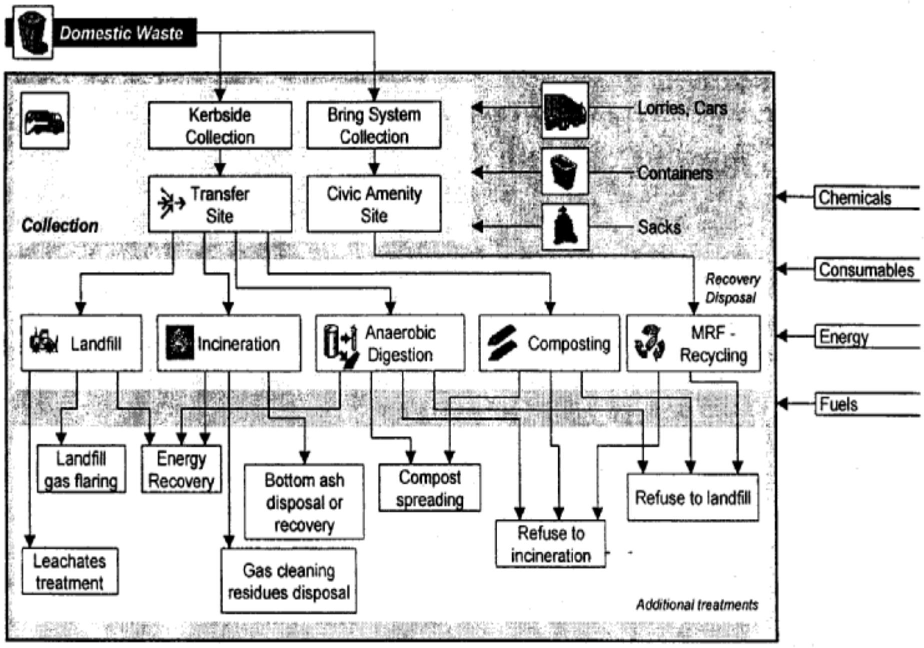

Figure 1: Scope of the *WISARD* tool

The functional unit includes waste generated over a year to enable possible seasonal variations in quantity and quality (occurring as a result of tourist flows) to be taken into account.

System boundaries/space and time

The tool takes into account all the stages in the management and processing of the waste, from the household front door through to the technically controlled disposal or recovery of the waste.

The upstream limit of the system is the "resource", represented by the refuse produced. The tool does not take into account either the production or use of the consumable items which will become this resource after use. This means that the analysis cannot be considered as being from "the cradle to the grave", as the departure point of the system is the refuse produced.

The model takes into account household waste and CA/bring system wastes. Commercial waste can be included provided its composition is similar to that of household waste.

Important note: the estimation of the waste quantity should not take into account the waste being home composted, as the treatment of home-composted waste (i.e. digestion process and emission to atmosphere) is not yet part of the tool.

-

Management of municipal solid waste is divided into two major sections: collection and processing.

-

Collection

The tool takes the following elements into account:

- production, use and end of useful life of the skips, containers and collection sacks;
- use of the collection vehicles;
- production, maintenance and end of useful life of the collection vehicles;
- collection at a transfer site or amenity tip. The construction, use or demolition of the site is taken into account; and
- transportation to a processing or recovery unit.

Collections are either door-to-door or brought by the individual. In the event of collections brought in by individuals, the possible use of private vehicles to firing the refuse to a terminal or amenity tip can also be taken into account.

For a given scenario, the resource in the form of refuse being the base definition, the user can define as many collection scenarios as he/she wishes.

Processing

The tool takes the following elements into account:

- Thermal treatment by incineration. Various process methods can be described for the atmospheric emissions (dust separation, dry, semi-dry or water treatments, specific, non- catalytic treatment of the nitrogen oxides, specific treatment of the dioxins and heavy metals by passing them over activated carbon). Likewise, various types of energy recovery can be taken into account. What happens to the solid by-products from the incineration, clinkers, residue from emission purification, scrap iron and aluminium waste is also taken into account (transportation, processing or recovery).
- Composting with sorting and possible recycling of glass, scrap iron, aluminium and -mixed plastics. Transportation and spreading of the compost produced are also taken into account.
- Anaerobic digestion with sorting and possible recycling of glass, scrap iron, aluminium and mixed plastics. The transportation and application of the refined product are also taken into account.
- Sorting and recycling of packaging, newspapers and magazines.

- Landfill with treatment of the landfill gas (flaring of furnace combustion) and the leached products (evaporation/incineration, treatment in purification stations on or off-site)

Construction, operation and end of the useful life (by demolition or covering over in the case of burial sites) of the sites are taken into account. Movement of site machinery is also taken into account using the combustion and consumption of the diesel.

In general only normal operation is taken into account for all the sites. For example, this excludes fires on the landfill sites and the burning of compost.

Time boundaries

The functional unit used in *WISARD* refers to municipal solid waste treatment over a period of one year.

In the case of collections and operations on some sites, such as sorting and incineration, transportation or processing dates correspond to the same period of a year, give or take a few days. The relative emissions into the atmosphere or water ~e place within the same period of time.

By contrast, emissions on other sites may be deferred by a few weeks (composting) or even by up to several decades, in the case of landfill.

In the latter case the system takes into account first the aerobic reactions and then the anaerobic reactions associated with the fermentation of rotting wastes, which produce landfill gas and leached products through the infiltration of rainwater.

The time boundary is set at the end of the landfill gas formation phase, in other words, 100 years after the waste has been deposited.

Appropriate Data

The choice of data used in *WISARD* should reflect the question being asked. For example, 'average' plant data maybe appropriate in modelling current situations, whereas "best practice" data should be used for examining future strategies.

Allocation rules

During data collection, methodological guidance was issued by a consultant to insure that all data collections were performed on a consistent basis.

So as to model waste treatments, additional allocation rules have been used. These are described in the sections to follow (8 to 17). It should be noted that the allocation principles are specific for the goal of the tool, especially considering the functional unit that has been chosen.

Avoided impacts

WISARD uses the avoided burden methodology as described in the ISO 140412 standards. The -avoided inputs and outputs used can be broken down into energy and materials. Each of these
will be discussed in turn.

1.4 Modelling of Energy Recovery

WISARD calculates and assigns credits to those scenarios where landfill, incineration and -anaerobic digestion are producing energy from waste. This energy may be in the form of either electricity or steam production. For the steam production, the user has the option of using the default fuel source to generate an equivalent quantity of steam or alternatively, the user can describe the fuel source by modifying a disposal method to suit existing conditions.

For the avoided production of electricity, *WISARD* assumes that the fuel source would be 100% ~ coal. That is, it is the avoided use of marginal electricity as opposed to base load electricity.

1.5 Modelling of recycling

This is dependent on the recycled and virgin products

Some of the process paths allow all or some of the municipal solid waste to be treated and fulfil the function analysed. However, some treatment sites can also make provision for one or more -additional functions:

- production of materials reused by industry (recycling after sorting, recovery of bottom I ash, sorting of the composting or anaerobic digestion sites),
- production of organic changes (composting, anaerobic digestion),
- energy production (incineration, anaerobic digestion, landfilling).

To identify the appropriate avoided impacts, the user must consider the following questions

1. What is the composition of the material being recycled?

The composition of the material being recycled can be used to define the recovery path of
municipal solid packaging material. The path/s which are representative of the current situation .in the UK, or that in the near future, have been taken into account in WISARD with the ~ agreement with the relevant manufacturers.

2. *What is the recycled material replacing (that is, by recycling this material what is it avoiding ~ the production of)?*

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2 ISO 14041 -"Environmental management -Life cycle assessment -Goal and scope definition and inventory analysis" October I 1998

The recycling/recovery paths that are currently used in France, or which may be used in the near future, have been taken into account within WISARD. The Ecobilan Group has obtained the appropriate permissions from the relevant manufacturers before using their data in the software.

3. *What is the mass of material being avoided by recycling 1 kg of the same material?*
4. *4. Which of the flows/Impacts are taken into account and which are not.*

The answers to these questions are given in the table 'Description Of Recycling Modules For Various Categories Of Municipal solid Waste' in Section 0.

In some cases, however, (recycling of scrap metal, some paper and cardboard, glass bottle bank), the recycled material or the reused product replaces a mixture of new and recycled material. The question then arises of the impact of making the recycled material3 available in the replaced process route.

The methodology developed for the French Environment Agency (Ademe) as part of the project, relating to the creation of a database for the production of packaging materials, proposes the following distribution of the environmental impact between the refuse production path and its recycling path:

- transportation from the site of production of the refuse to a sorting centre for municipal solid waste (for example) is treated as "inevitable" transportation -one way or another, municipal solid waste has to be dealt with. It is ascribed to the production path of the refuse. Thus it can be considered that the stock of material drawn upon to obtain "secondary materials" is practically created.

- extraction of the scrap metal, old paper or broken glass from the stock, possible transportation of these to the processing site (crushing for some of the scrap metal, sorting and compaction of old paper, crushing and washing of the incineration residue), the treatment itself and then the transportation to the site of use in the form of "secondary materials" are attributed to their recycling path.

This is not the only possible distribution of the environmental costs, but it does have the advantage of being applicable to the five packaging materials (steel, aluminium, paper and

3 The same question arises when calculating the environmental cost of the recycled paper sack used during the collection, for example. In contrast, it does not arise in the case most commonly encountered in *WISA.RD,* where a recycled material
replaces a new material. In actual fact the objectives for this tool differ from those of the "Packaging Materials" database created by Ecobilan for Ademe (France) concerning the entire life cycle of the packaging. In this case the objectives are:
.to calculate the overall environmental cost of recycling a material, incorporating the gains due to the impacts avoided by the non-production of a substitute material. There is no requirement to distribute the cost of recycling among the waste and the recycled product.

-to be able to compare packaging processing solutions, which dictates the need to take into consideration the Systems which fulfil the same function: the collection and treatment of municipal solid waste.

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cardboard, plastics and glass). The same distribution was selected for this project, not only for the reason outlined above, but also with an eye to uniformity between the work carried out with *WISARD* in France.

1.6 Abnormal operations

Abnormal operations are outside the scope of the tool and have not been included. An example of an abnormal operation would be afire at a landfill.

WISARD limitations

It should be noted that while *WISARD* considers some environmental aspects, it does not address human or environmental safety, legal compliance issues or nuisance issues (e.g. litter, dust and visual amenities). *WISARD* is only one tool in the toolbox. There are other tools such as risk assessment and environmental impact assessments, which should be used for other functions such as assessing the safety of particular processes or the siting of particular waste handling or treatment plants.